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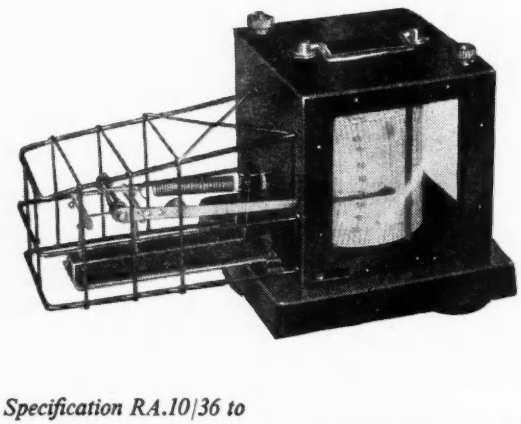

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DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

September, 1947 Vol. VIII. No. 9

Editor WILLIAM E. DICK, B.Sc. F.L.S.

Editorial Office: 244 High Holborn, W.C.1. Tel. Chancery 6518
Published by Jarrold & Sons Ltd. Norwich. Tel. 21441

Advertisement Office: 161 Cheapside E.C.2. Tel. Met 9729

The Progress of Science

Salaries of Science Masters

In our note and comment on the British Association Conference dealing with "Scientific Research and Industrial Planning", we gave prominence to a speech in which Dr. J. A. Lauwerys pointed out how the present niggardly salary scales for graduate school-teachers would endanger the whole of our higher educational effort, and this would particularly affect the teaching of science. Eighteen months of experience have now confirmed his view, and a recent correspondence in *The Times* shows that those concerned with all branches of higher education are being driven to protest vigorously. The correspondence, opened by Sir Richard Livingstone, one of our foremost university educationists, contained expressions of opinion from practically all sections of the higher educational field. The writers stressed the facts that the key to the whole of higher education lies in the teaching of the higher forms in schools, particularly the sixth forms of grammar schools; that such teaching can be properly done only by graduates; and that the present salary scales are relentlessly driving graduates elsewhere. Sir Ernest Graham-Little recalled the hostile reception which these scales received in the House of Commons debate on February 20, 1945. On that occasion six of the eight university M.P.s took part in the debate, and all condemned the scales.

In *The Times* correspondence there were the usual one or two writers who took the old line that teachers should be prepared to teach merely for the love of their vocation, irrespective of salary. But the rest of the letters produced an overwhelming mass of evidence to show that it is the salary scales that must be corrected if our higher education is to be rescued from a perilous situation.

Let us note a few of the facts they revealed. Outside the London area the maximum salary for a graduate teacher is £655. A not unusual case is that of an honours science graduate who, after teaching the sixth form for six years, was being rewarded with the princely sum of £457 a year; in this instance, the sheer necessity of supporting a family deprived the schools of yet another teacher, who migrated to an industrial post carrying double the salary. The poor financial prospects, coupled with certain other unnecessary burdens in conditions of employment, are reducing recruitment to the profession to a very seriously low figure. It has been said that not one of this year's Oxford graduates in science or mathematics is going into school teaching. One university appointments board had recently on its books 230 applications for junior mathematics teachers and could not satisfy one of them. Another has only been able to fill 14 out of 300 secondary school posts in science and mathematics, and only 111 out of about 500 posts requiring graduates in other subjects. At the same time graduates already in national grammar schools are being compelled for financial reasons to leave them for other professions at a truly frightening rate—the loss, between April 1945 and December 1946, amounted to 906.

As the head of a university teachers' training department quoted by Sir Richard Livingstone put it, "the Burnham Committee seems to have done all it can to discourage the first-class graduates from taking up teaching in secondary schools." To this we may add the point made by Dr. Lauwerys, that the scales seem to be designed to dissuade those who have decided to teach from graduating first and thus qualifying for the higher parts of school teaching —graduates get a mere £50 addition to their salaries, which means that (even omitting calculations of compound interest) it takes them twelve years to catch up on the salaries they have lost by spending two extra years in taking a degree.

The need for a great increase in the output of our universities, especially the output of scientists, has been clearly established in the Barlow Committee Report and elsewhere. But it seems that little attempt has been made to work out the implications of this need. The output of the universities depends on the quality of the young men and women they receive from the schools, and that in turn depends on the quality of their school-teachers, especially sixth-form teachers. It is scarcely an exaggeration to say that the quality of the men who do our sixth-form teaching is the keystone of our whole educational system, and therefore—to skip to one of the important end links in a longish causal chain—the key to that scientific reform of our industrial technique which is so

much needed if Britain is to remain a first-class nation. Of course, industry and the Civil Service also want first-class men; but the question that must be faced is this: are the first-class men going to be more valuable to the nation by doing an immediate job in one of these latter positions, or by doing the key work of training many times their own number to do these jobs in some three years' time? Any plan for the rational use of our best brain-power would, we believe, give heavy emphasis to the latter aspect, and would, therefore, take the obvious step of attracting the brains to the schools where they are needed by raising the salaries of graduate teachers to at least a level competitive with those holding in industry and the Civil Service. The Burnham Committee made a serious blunder from the national point of view when it fixed the present scales and that blunder must be corrected. This must be done quickly, for the loss of the supply of graduates for a year or two will take many years to make up.

Southampton County Laboratory

JUST off the Salisbury-Basingstoke road and near Micheldever, is Britain's first County Laboratory. Until a year or so ago it could have been described as the *only* County Laboratory in the United Kingdom.

Over twenty years ago the Surveyor to the County of Southampton—usually known as Hampshire—decided to have complete scientific control over the construction and repair of his roads and bridges. This was before the Department of Scientific and Industrial Research had started its present Road Research Laboratory. Though primarily concerned with roads and associated problems the County Laboratory now also tests for its Council the calorific value of fuels as well as the suitability of lubricating oils.

The road materials on which it carries out tests include asphalt, concrete blankets, aggregates for asphalt and bituminous mixtures and gradings. It considers, interprets and revises specifications; it technically directs the manufacture of the materials used in the construction and maintenance of road works. In fact, it is the control laboratory for the County's adjacent asphalt plant which is of the latest, thermostatically-controlled type and manufactures tar macadams, bituminous mixtures and asphalt carpets.

The laboratory has done considerable experimental work in connexion with the blending of bitumens. Adhesion tests are made on new types of tars and bitumens.

In co-operation with the University College of Southampton, improvements have been made in the composition of concretes for the construction of bridges. The Laboratory has worked out a most satisfactory formula using nearly 50% less cement than was formerly considered possible.

Among other work is the testing of aggregates for grading, flakiness, elongation indices and specific gravity, as well as water absorption and sieve tests.

So that problems of soil mechanics can be solved scientifically, apparatus is being assembled that will enable fairly comprehensive classification, surveying and testing of soils to be undertaken. A special piece of work has been on the hydrophitic nature of Hampshire gravel, which makes the material useless for tar spraying surface aggregate. The water film prevents the tar adhering.

Just before the war it was decided to move the laboratory to new premises at Winchester, since the wide field of activities demands specially designed buildings—certain tests, such as compression of concrete, having to be contracted out at the moment.

The laboratory also carries out tests at the request of the urban districts within the County. Its latest addition is a travelling field laboratory for sampling and analysing on the spot. With this strict control at the receiving end contractors are precise in delivering to specification.

Recently a similar laboratory has been started at Wakefield for the West Riding of Yorkshire and another in Cornwall.

Scientific Aid in Bibliography

SIXTEENTH and seventeenth century authors and printers had a disconcerting habit of making frequent alterations during the printing of a single edition of a book—often calculated stop-press changes which they considered to be improvements. By comparing different copies of the same edition—collating is the technical word—modern critical bibliographers can often gain a tremendous amount of information from the alterations: first, general information about early printing and publishing methods; and secondly, particular information concerning the history of the particular book, the state of the author's mind, and the like. Naturally the interpretation of differences, once detected, involves the highest forms of judgment; but at present this has to be preceded by the very lengthy and tedious labour of comparing copies word by word. Even when comparing only two copies the labour is bad enough; but it has been suggested, for example, that much could be learnt by collating the extant copies of Shakespeare's First Folio, which number some two hundred and thirty—a task that would seem at present to be prohibitive. Bibliographers and the literary, technical and other historians who use their results at second hand, will, therefore, be more than pleased if success attends attempts that are now being made to mechanise the process of comparison.

The germ of the method arises from an abortive wartime technique. Everybody knows how much was learnt about the enemies' fortifications and active defences by the comparison of photographs of the same scene taken at different times—also a process of great tedium. At one period it was proposed to mechanise comparison by arranging for the two views to be projected on the same screen in quick alternation accurately superimposed. Any unaltered parts of the picture, so the theory went, would appear steady; but changes would be revealed by wobbles and flickers. The method was not a success, largely because of the virtual impossibility of ensuring that the two photographs should be taken from the same point of view, at the same angle and the same lighting conditions.

However, it would clearly be a much easier matter to use this method to compare flat surfaces like book pages which can be photographed at leisure in conditions completely at the disposal of the operator. That was the idea that struck Charlton Hinman of the Bibliographical Society of America, and preliminary trials of its application to the collation problem shows considerable promise of success.*

* *See* Charlton Hinman: "Mechanical Collation: A Preliminary Report", *The Papers of the Bibliographical Society of America*, Volume 41 (1947), 99–106.

In the experimental work the two copies that were to be compared were microfilmed. Images of the two microfilms are then projected in quick alternation on a screen by means of a double shutter which alternately obscures the two projection lenses, and changes in the text are very rapidly and easily detected by pronounced wobbling and flickering. The inventor confesses that in the experimental apparatus the process of adjusting the images to give accurate superimposition was about as lengthy as the old word-by-word comparison would have been. But it seems likely that a well-designed apparatus would reduce the adjustment problem to negligible proportions.

Suction Slots and Aerofoils

THE ever-increasing size of runways demanded by modern aircraft is causing much concern, because of the constructional difficulties entailed, and the waste of valuable land. Much attention is therefore being paid to methods of reducing the distance which an aircraft must cover to become airborne, or to land. A method which has been considered for many years is now well advanced in the experimental stage.

The factor which determines the take-off and landing performance of an aircraft is the maximum lift which the wings are capable of exerting. A conventional wing section continues to give increasing lift as the angle of incidence of the airstream increases; this occurs for angles of incidence up to 15° but with any further increase in the angle of incidence the airstream over the wing breaks away from the surface and becomes turbulent, with the result that the wing ceases to lift. The wing is then said to be stalled. (Fig. 1*a*).

The first attempts to prevent this stalling, using 'boundary layer control'—the boundary layer, as the name implies, is the layer of air adjacent to the body surface, which due to friction is moving much more slowly than the general mass of air—were made by cutting a slot in the upper surface about halfway back, through which air could be sucked. (Fig. 1*b*). When the boundary layer started breaking away, leading to stalling, suction was applied at the slot and the airstream then resumed its smooth flow over the remainder of the surface. The lift exerted by the wing showed a marked increase.

Wing sections of modern high speed aircraft have become much thinner, with the result that artificial means of increasing the lifting power have become more urgent. A new approach to the problem is not merely to experiment with slots cut in existing aerofoil sections, but to design completely new sections from theoretical considerations, in which the slot, and the suction effects, are an integral part. (Fig. 1*c*). An exhibit at the National Physical Laboratory's 'open day' illustrated such a method; this was a wing section designed by Lighthill in which the suction slot was actually at the leading edge.

The effect of this suction is apparent at once from wool tufts distributed over the surface; with no suction these oscillate wildly when the angle of incidence is increased over 15°, indicating a stalled condition of flow. As soon as the fan which sucks air through the slot is turned on, the tufts settle and lie downstream, the lift generated being considerably increased.

Any system of 'boundary layer control' is, unfortunately not immediately applicable to aircraft, as the amount of air which must be sucked through the slot is still prohibitively large for practical purposes. With further knowledge of the optimum position and size of the slots, however, it should be possible to reduce this, and in addition the increasing use of gas turbines, which suck in large volumes of air, will probably allow for the development of a combined system.

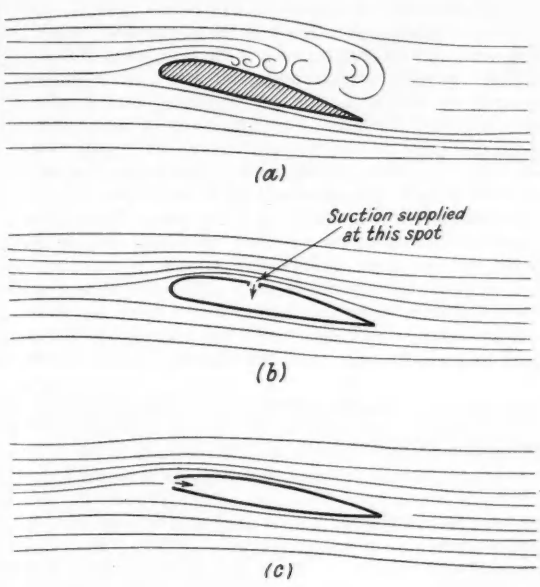


FIG. 1.—(*a*) A conventional wing section stalls at an angle of incidence of 16 deg. The airflow can no longer adhere to the top surface, and breaks away, becoming turbulent. Stalling is accompanied by a severe loss in lift.
(*b*) The same section as in (*a*) but with suction from the interior of the wing applied at the slot. Smooth flow has been resumed, owing to the airstream being sucked back, with consequent benefit to the lift.
(*c*) An illustrative example of a much thinner wing section which has been designed with a suction slot as an integral part. In this case the slot is located at the leading edge.

Underground Gasification in the U.S.A.

THE Americans are following up the pioneer Russian work on the underground gasification of coal*—work suggested by Sir William Ramsay in 1912 and mentioned in a British patent taken out in 1909. Large scale experiments are now proceeding in the United States to which close attention is being paid by British fuel experts.

In the States a full-scale test was started in January this year at a bituminous mine owned by the Alabama Power Company. This, the first practical investigation of underground gasification to be made outside Soviet Russia, was begun with the co-operation of the Bureau of Mines and the Southern Research Institute.

A small horizontal vein of coal 3 feet thick and

* *See* DISCOVERY, 1944, Vol. 5, pp. 88–90, pp. 144–145.

containing about 900 tons, with a relatively shallow overburden—30 feet—was selected for the experiment. (Fig. 2.) Engineers cut through the sides of the seam so as to isolate it from the main coal deposits, and then cut a U-shaped combustion duct or gallery six feet wide parallel to and running round the seam. One arm of the U was 140 feet long, the other 170 feet and the gallery joining them was 40 feet long. Bags of clay were placed along the walls farthest from the experimental seam to prevent the fire spreading to the main seam. A 24-inch pipe from an air-blower, a 2-inch steam pipe and a 24-inch exhaust gas stack, 40 feet high, were sealed into each of the two entrances of the combustion duct. This arrangement was made so that air or steam could be blown into either of the two entrances and allowed the gases formed by the burning coal to leave through the stack in the opposite gallery. This alternative type of flow would, it was thought, minimise any unequal consumption of coal.

To determine differences in pressure, composition of the gases and temperatures at various points, 4-inch pipes were sunk vertically through the overburden to the top of the seam, and capped, with connexions through the caps for insertion of thermo-couples and for taking gas samples and pressure measurements. (Figs. 3 and 4.) Similar connexions were installed at the entrance to eight horizontal shafts connecting with the combustion galleries. At these entrances direct observation of the progress of the burning could be made through peepholes of Pyrex glass. (Figs. 3 and 6.)

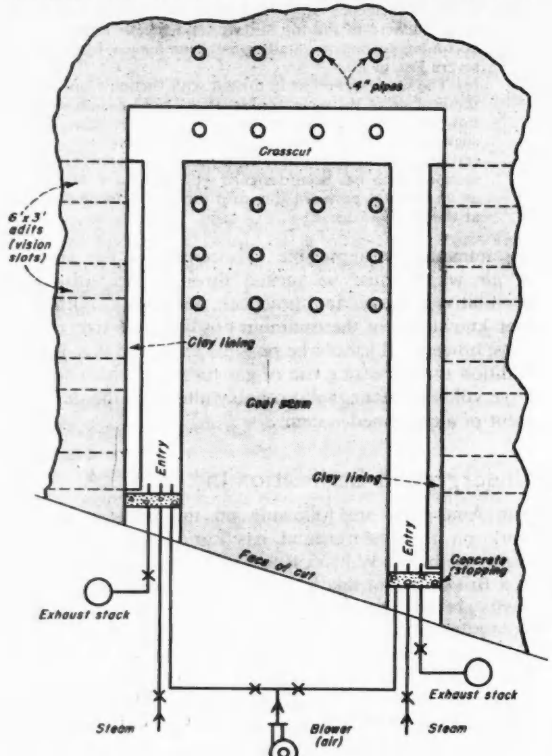


FIG. 2.—Plan of the underground gasification undertaking at Gorgas, Alabama. (From *Chemical Engineering*, April 1947.)

The coal was fired by dropping incendiary bombs through some of the vertical 4-inch pipes on to broken coal in the gallery joining the two arms of the combustion galleries. Because of the relatively thin overburden high steam and air pressures could not be used, so that temperatures were not as high as was hoped. In the burning area temperatures reached 2000°F.–2200°F. during air blasts, with an average temperature however of between 1300°F. and 1500°F.

Several types of operation were carried out in this 'underground gasworks' at Gorgas, Alabama. The principal ones used (*a*) *a continuous air blast*, the product then being mainly carbon monoxide diluted with nitrogen and (*b*) *blasts of air and of steam*, in alternation, which yields 'water gas', whose combustible fraction includes hydrogen in addition to carbon monoxide. Some runs with an oxygen blast in place of air were tried, and the resultant gas had a higher calorific value.*

When the coal has been fully gasified the overburden is to be scraped off with bulldozers to lay bare the burnt seam. This will then show how much has been burnt away and give other pointers as to whether or not underground gasification is an economic proposition.

Fuel experts in this country are taking a great interest in these American experiments, as well as the experiments soon to be carried out in Belgium. Already various sites in this country where similar work might be profitably carried out have been inspected by members of the Fuel Research Laboratory working in conjunction with the Geological Survey. A report on their investigations has been drawn up and submitted to the Ministry of Fuel and Power who are now considering it.

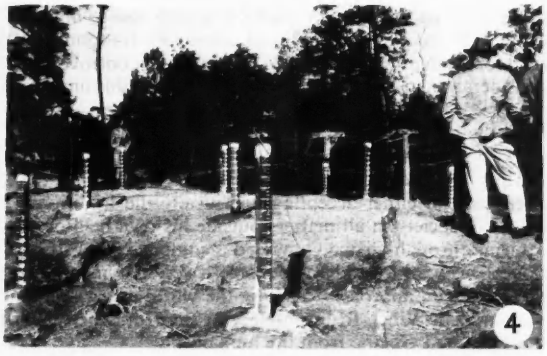
Underground gasification would not, of course, provide any miraculous answer to Britain's fuel problems. Among the principal difficulties facing underground gasification operations are:

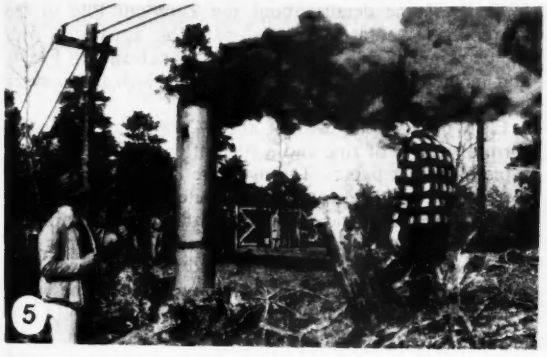
(1) The low calorific value of the gas produced by air blasts.
(2) This gas would have to be used near the site for economic working.
(3) The gas could not be used as a synthesis gas—i.e. to make other, more valuable, compounds.
(4) To provide a better heating gas, oxygen blasts might have to be used, which would prove expensive.

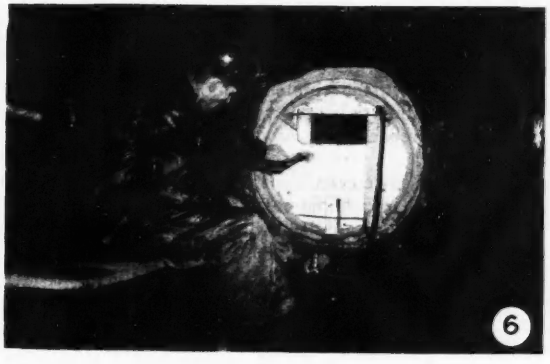
On the other side of the picture, it would seem that because of the saving of manpower and machinery, coal of a poor quality or that mixed with inert material might be able to be utilised by this method, where normal methods of deep mining would be too costly to be economical.

A decision on whether or not we are going to have experiments on underground gasification in this country will, however, be made soon.

* The gas obtained with the air blast had the low calorific value of 55 B.Th.U. per cu. ft., while production was estimated at 1400 cu. ft. per minute. The water gas made during the steam run had a value of 222 B.Th.U. per cu. ft., and 220 cu. ft. per minute was made. Owing to limitation of oxygen equipment the maximum oxygen input was 200 cu. ft. per minute. During the three-hour run, using a 60% oxygen and 40% steam blast, 1000 cu. ft. of gas was produced per hour of a value of 150 B.Th.U. per cu. ft.







Photographs of the Gorgas experiment. Fig 3 shows openings into the isolated seam for observation of the burning coal; at the top of the picture are seen the pipes for sampling gas and recording temperatures. FIG. 4.—A closer view of the gas-sampling pipes and thermo-couple leads. FIG. 5.—Smoke and gas from the burning coal issuing from one of the 40 ft. exhaust stacks. FIG. 6.—An observation point where the burning of the coal can be watched through a heat-proof glass window. Thermo-couple and gas leads are fitted to the door of the observation bay.

Science and Humanism

THE consequences of the division of our cultural tradition and the education which preserves that tradition into two almost completely exclusive parts, the 'sciences' and the 'humanities', are fast becoming so severe that the need to find methods that will end this unnatural dichotomy is one of the more pressing problems of our times.

At a time when mankind is beginning to take the first steps towards the attempt that must be made to plan its future co-operatively, instead of leaving it to evolve as the resultant effect of purely individual efforts—at such a time the world needs citizens who can see life as a whole. Instead, the very best of our educational institutions give us our citizens by half measures: few of the people they turn out are equipped by their educational training to see our complex civilisation as a whole and as a result they are in no position to see what future trends might be.

The origins of the unfortunate division between science and the humanities are discussed by Professor J. D. Bernal in an article in the May issue of *Universities Quarterly*, and in his usual provocative and stimulating way he suggests how the educational regime could be altered so that, instead of the half-citizens who have specialised in science or the humanities but know next to nothing of the potentialities which an appreciation of both opens up, it could produce complete citizens capable of taking an integrated view of civilisation as a whole.

The division, says Professor Bernal, originated in the earliest civilisations from the breakdown of the primitive unity between thinking and doing—"with the divisions of society into rulers who dominated men by words of power, and mechanics who worked with their hands". Only in Renaissance times did the knowledge of the doers come to be admitted as true 'learning' in the form of natural science. In Greek and in Renaissance times the literary tradition had grafted upon it the idea of education as a gentleman—the use of education as a mark of class superiority. The gentleman as a born ruler has passed away, but the tradition in humanistic education remains. Yet whatever its faults, humanistic education was an attempt to provide an integrated view of the world (though unfortunately a one-sided and largely false view).

Scientific education on the contrary has grown up in a spirit of practice, which has its advantages, but also the disadvantage of encouraging ever narrower specialisation and a strong tendency to avoid the formulation of

integrated conceptions. In England science rose to importance in a time of great political upheaval. Its founders, therefore, intentionally avoided political and controversial considerations. Mere inertia of scientific institutions has preserved in this country an aloofness of the scientist from the political and social considerations related to his work, which is no longer justified.

Thus the scientist, trained only in his science, has the alternative of either accepting uncritically the traditional beliefs of society in all matters outside his own field or of carrying through virtually unaided a complete reconstruction of his world-view. In fact only a very few men have even made an approach to seeing the world as a whole—Leonardo da Vinci, for example, starting from the scientific side, and Goethe from the humanistic.

In fact the task of integrating together the sciences and the humanities is too great a task for the individual. It must be a task of the educational system as a whole. The difficulties are enormous, because there do not exist at present people with the required outlook to do the teaching. We can, therefore, only seek ways of beginning the integration and preparing the way for future generations to accomplish it.

In a present-day curriculum there is no room to squeeze a little science into humanitarian studies or vice versa. But in fact curricula are filled with superfluous junk, once useful but now retained by mere scholastic inertia (until sheer pressure of new-growing knowledge forces some haphazard pruning of the old). Teachers do not have the time to consider fundamentally what they teach. The question of curricula must, therefore, be attacked in a revolutionary way—"What we need", says Professor Bernal, "are appointed whole-time university commissions to revise curricula, not according to their opinions but according to careful operational research both on the justifications of the existing curricula and the effects of the teaching in the subsequent work and life of the students. Essentially what we are aiming at in both arts and science is to reduce the amount of learning in order to be able to increase the range and depth of understanding." We should then be able to add some science to the arts courses and some arts to the science. There are, in fact, very few people competent to teach humanities to the scientist, or vice versa, but a start must be made now in order that posterity may improve on it.

Professor Bernal also suggests the introduction of new methods which would force the intimate co-operation of the two sets of half-citizens—for example the carrying out of certain types of surveys by joint staff-student teams of mixed disciplines. "The question of housing, for instance," he writes, "is one which involves every single subject that is included in both faculties, from theology to chemistry. Houses are not only made of bricks and mortar, they are part of the tradition of British history; they do not stand by themselves, but as units in the social complex of the neighbourhood; and the reactions of their inhabitants provide a fascinating field for applied psychology. Why can we not find room in our curricula for the undertaking by staff and students together of such general projects? It is there, in examining and studying real practical difficulties, that the varied human and scientific disciplines could become effectively mixed. It is there that the student could receive a foretaste of the experience which he is bound to receive when he goes out into the world."

The Zamboni Pile

THE Zamboni Pile is the source of the electric current upon which the working of the British military infra-red equipment described in DISCOVERY recently (Vol. 8, p. 67, March 1947) depends, and after the appearance of that note in "Progress of Science" several readers asked for more details about this kind of battery which combines extreme compactness and a supply of high-voltage current. We are now able to answer certain queries raised by readers. It is also possible to trace the development of the Zamboni Pile used during the war right back to an ancient prototype which has kept two bells ringing at Oxford since 1840.

Firstly, some details about the Zamboni Pile in the Clarendon Laboratory at Oxford. The apparatus with the two ringing bells is shown diagrammatically in Fig. 8, and includes two piles, each about one inch in diameter and five inches high.

Each pile is composed of about 2000 elements in the form of a strip of zinc and a strip of copper separated by a piece of filter paper. The moisture in the paper is sufficient for each element to constitute an electrical cell. Each pile has its outer surface insulated with a coating of sulphur. The two piles are arranged with their upper ends of opposite polarity firmly connected by a brass rod, and a small bell is fixed on each of the lower ends. The whole produces a potential difference of several thousand volts, but would, of course, give only a minute current for an inappreciable period. A pith ball hangs on a fine thread between the two bells, and starting, say, in contact with the positive terminal, acquires a positive charge: it is thus repelled and attracted to the negative terminal,

FIG. 7.—Modern Zamboni piles. The larger unit (one of which is sectioned to show the interior, and the elements held in position by a spring) generates a thousand volts; the smaller unit gives one hundred volts. (*Crown copyright, reproduced by courtesy of the Director, Admiralty Research Laboratory.*)

acquires a negative charge, is repelled, and so on. It thus discharges the cells by carrying an electrostatic charge from one bell terminal to the other. This electrostatic charge is so minute that the pith ball has been ringing the bells continuously since 1840.

The existence of these Oxford Piles was brought to the attention of the Admiralty scientists and they recognised that such batteries which would provide a high-voltage current at very low amperage was just what they were looking for as a source of current for the infra-red equipment under development. They accordingly consulted the Clarendon Laboratory and were there given the 'plans' of the Zamboni Pile of 1840. An improved form of the pile was designed; metal foil was used in making up the series of electric cells composing each pile, and a coating of manganese dioxide was added to act as a depolarising agent. It was thus possible to make a dry battery that would be only a few ounces in weight, and yet generate electricity at a thousand volts (Fig. 7). These piles were put into mass production, and their efficiency coupled with extreme lightness contributed materially to the ultimate success of British infra-red equipment when it was used on naval, military and aerial operations.

The Marconi Jubilee

SOME might choose 1895 as the date for the beginnings of radio communications—the year in which Marconi began his experiments and achieved transmission over a range of 1½ miles. Others might take 1896—when Marconi arrived in England and convinced the Post Office that he had developed a practical technique. The choice is purely arbitrary, but in some ways 1897 is as good a date as any. It marks the acceptance of the importance and practicability of radio by the commercial world, the actual event which signified that acceptance being the formation, on July 20, 1897, of the "Wireless Telegraph and Signal Company, Ltd.", which three years later became "Marconi's Wireless Telegraphy Company, Ltd." The Company has now marked its jubilee by the issue of an amply illustrated historical booklet.

The article by Lt.-Col. Chetwode Crawly which we published in May 1946 (pp. 150–2) absolves us from the necessity of repeating either the history of radio in general or that of the part played in it by the Marconi Company. But we may take the opportunity to recall briefly one of the more remarkable revolutions in radio technique in which Marconi's took the lead. After the First World War there was great interest in the use of wireless for Imperial communications, and the Imperial Conference of 1921 set in motion the construction of a chain of stations. At the time a generally accepted principle of radio was "the longer the wavelength, the greater the range", and the new stations were accordingly planned to operate on some thousands of metres. Short waves were thought to be economically valueless and had accordingly been handed over to the amateurs as a region of the ether in which they could experiment or play without danger of interfering with the serious business of radio. Almost everything then known about short-wave transmission had been discovered by amateurs. They had achieved some remarkable ranges, but on the whole the commercial radio world had taken little notice.

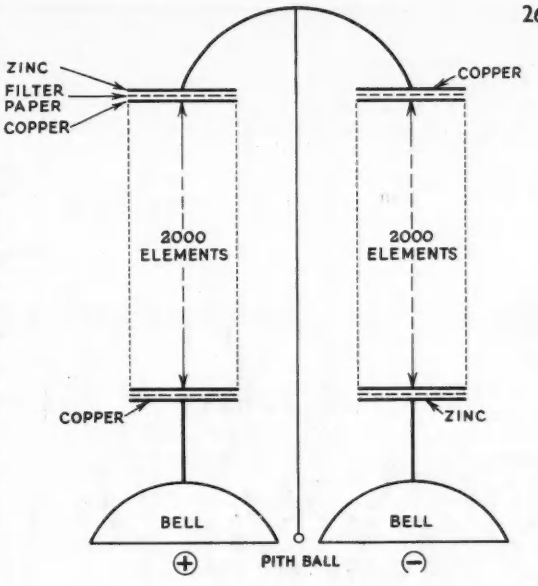


FIG. 8.

Marconi's, however, were not content. They returned to experiments on one of the earliest ideas of their founder, the use of reflector aerials to transmit signals in beams; and they combined this with research on the use of short waves. The work met with great success. It was found that these methods gave much greater ranges with much less power, and eventually the Company approached the Post Office with the astonishing proposal that they should be allowed to construct a chain of Imperial radio communications using only 1/50th the power and involving only 1/10th the cost of the original scheme. Their claims were fully vindicated, the Post Office cancelled the earlier plans and on July 28, 1924, entered into a contract with Marconi's for putting their new system into effect. This was the real beginning of reliable long-distance radio communications.

Britain's First Atomic Pile

BRITAIN'S first atomic pile started up at the Atomic Energy Research Establishment, Harwell, last month.

This pile, known as the Gleep (Graphite Low Energy Experimental Pile), is the first major unit to be completed at Harwell, and has been built primarily for experimental purposes. It will, however, be used for the time being, until the more powerful Harwell pile comes into operation in 1948, for the production of small quantities of radio-active isotopes for biological and medical research.

The pile has been designed largely by a New Zealand group of scientists working at Harwell. Many British scientists have contributed to the production of the pure graphite and uranium, and have designed and produced the instruments required for the pile. Considerable assistance has also been obtained from Canada, particularly in the testing of graphite.

The engineering and constructional work on the pile has been completed in fifteen months from the start of work on the site.

Lavoisier's Laboratory

French Science—Past and Present

E. M. FRIEDWALD, Licencié-ès-Sciences

Soon after the American forces took up their quarters in France, a pamphlet was issued to them by the U.S. Army authorities to give them some idea of the country in which they were to be stationed. The piece of information which most surprised the average American was the revelation of France's outstanding record in science, of the fact that she has contributed as much as any nation, indeed more than most, to the common heritage of science.

However, a broad survey of France's scientific achievements can be more than a mere record of a nation's contribution to scientific knowledge. For in the course of its long history French science has had its ups and downs, at times indisputably leading the world, at others receding into the background. Now these fluctuations can be traced to definite causes, and a short survey of French science in its historical and social setting can thus reveal at least some of the moral and material forces which have stimulated or hampered scientific progress. Today, when so much is said about the prerequisites and needs of science, it is not without interest to see what can be learned from the past. And because of its long history and fluctuating fortunes French science provides as good an observation ground as any.

The origins of French science go back as far as those of modern science itself. The Renaissance, which spread from Italy to France during the Wars of Italy in the first half of the sixteenth century, was the revival of the civilisation of the Ancients. It produced a blind admiration, particularly in the field of science, for everything the Ancients had laid down. Thus science became a mixture of the Bible, Aristotle and witchcraft. It was only when men began to liberate themselves from the hold of these authorities, and to study nature with unprejudiced minds, that modern science may be said to have been born. However, it had, on the one hand, to contend with uncritical belief in the Ancients and traditional resistance to innovation, and on the other to overcome the opposition of the Church. Nowhere was the struggle more difficult than in France. There, in contrast to those of Italy, the Universities were completely dominated by theology and scholasticism, most of all the University of Paris which, established in 1200, was one of the oldest centres of learning in Europe. The most free from these barren influences, perhaps because of its proximity to the Mediterranean world, was the University of Montpellier (1220), renowned as an active centre for the study of biology and medicine. But this was one small islet in a sea of obscurantism, and it was to counteract the nefarious influence of the universities that Francis I in 1530 set up the 'Royal Lecturers' an institution which later developed into the

Collège Royal and later still into the *Collège de France*, a centre of humanism and modern thought. Indeed it is one of the salient features of French science that the universities played no part in its development until the latter part of the nineteenth century.

The setting up of the Royal Lecturers was the first significant reaction against scholasticism in France, and soon afterwards the rise of French scientific thought can be discerned. The first French scientists of international standing made their appearance in the sixteenth century, and it is noteworthy that most of them were amateurs, sometimes physicians but mostly magistrates, practising science as a hobby. The greatest of these was François Viète (1540–1603), lawyer and magistrate, the most outstanding mathematician of the century. He was among the first to employ letters to represent numbers, and laid the foundation for analytical trigonometry. Another great figure of that period was Ambroise Paré (1509–90) who, starting as an orderly in the Hôtel-Dieu hospital, became the most famous surgeon of the century. He did a great deal to improve surgical instruments and introduced the use of the ligature to stop bleeding in operations, at the same time abolishing the treatment of wounds with boiling oil. Yet another notable figure was Bernard Palissy (1510–89?) who first recognised in fossils the remains of animals and plants. Of the five great naturalists who revived the study of animals, dormant since Pliny, two were Frenchmen: Pierre Belon (1517–64), and Guillaume Rondelet (1507–66).

Thus in the course of the sixteenth century, in France as elsewhere in Europe, there was a distinct tendency to throw off the shackles of medieval obscurantism. But it was not until the seventeenth century that this movement gathered any great momentum, and modern science is considered to date from that time. Foremost in the ranks of its founders stands one of the greatest figures which France has contributed to the world of knowledge, René Descartes.

The Cartesian Impetus

Descartes (1596–1650) was an outsider to science, being by profession an army officer. But military life held no interest for him, and he soon quit it to dedicate himself for several years to meditation. As a result he decided to write a *Traité du monde* and, anticipating the opposition of the Church, retired to Holland, at that time the refuge of intellectual liberty. However, learning of the condemnation of Galileo, he cautiously destroyed the unfinished manuscript and instead published in 1637 his *Discours de la méthode*.

Great as was Galileo's contribution, it was left to Descartes to lay down the rules of modern scientific thought, and to evolve a new philosophy of science. His *Discours* was in fact the first manifesto of modern thought, the triumph of commonsense over nonsensical dogma. It finally demolished scholasticism and obscurantism, and set out to build in its place a new edifice of science based on strict rules of reasoning and deduction. It represented a veritable revolution in the approach to science and its philosophy, and its influence can be gauged by the fact that for a century the Cartesian system dominated scientific thought, only slowly giving place to the Newtonian system towards the middle of the eighteenth century.

Nowhere was this influence more strongly felt than in France though there, in the long run, it was to prove a not unmixed blessing. Indeed Descartes, perhaps because he was a mathematician, gave too much weight to reasoning and too little to observation and experimentation, and a too blind adherence to his method was later to prove detrimental to scientific progress in France. But at first it created the conditions essential for scientific development along modern lines, and that at the time when interest in the study of nature was being revived. Indeed in 1626 Louis XIII established the *Jardin du Roi* which was later to become the *Jardin des Plantes*, one of the most famous institutions for the study of natural science. Even more significant was the interest in science, inspired to a large extent by the vogue for Descartes, which at that time became fashionable in the higher circles of French society. In the salons conversations centred round the latest book of Descartes whose next work was awaited as eagerly as that of any fashionable novelist today. The atmosphere was favourable for one of the most glorious periods in the history of French science.

Descartes himself was not only a philosopher but also a scientist of genius. His most important contribution in this field was his invention of analytical geometry, one of the greatest steps ever made in the progress of the exact sciences.

The same discovery was made simultaneously and independently by Pierre de Fermat (1601–65), another magistrate, who became the greatest mathematician of his time. In his work pertaining to maxima and minima, he actually laid the foundation for the differential calculus which Newton and Leibniz, independently of each other, fully developed half a century later. He was a pioneer on the number theory and the author of the so-called 'last' theorem which has never been approved or disproved, though ever since his time it has exercised the minds of the greatest mathematicians. He also formulated the general principle of least time (in connexion with the travelling of light) and, together with Pascal, founded the mathematical theory of probability, which was later fully developed into a system by Laplace.

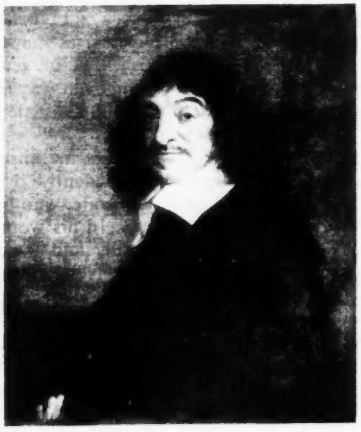
The third great genius of that period was Blaise Pascal (1623–62), who at the same time was one of the greatest philosophers, writers, mathematicians and physicists. At the age of 12 he wrote a treatise on acoustics, at 16 he produced a famous essay on conics, at 18 he invented the calculating machine, in his late 20's he enunciated the law of fluid pressures whence springs hydrostatics, and at thirty-one he founded the mathematical theory of probability. All this immense work was done in his spare time, for he regarded his scientific pursuits as a hobby.

Contemporaneous with those three giants were other scientists of the first order: the mathematicians Desargues and Roberval, the astronomers Gassendi and Picard, the physicist Mariotte. Indeed, it might be said that in the generation of Descartes French science was second to none. It was at that time that Colbert became the principal Minister to Louis XIV, and Colbert was a very enlightened man who saw in science a source of prestige and glory for his country. It was he who, in 1666, created the Academy of Sciences with the double purpose of counteracting the nefarious influence of the theology-ridden universities

Antoine-Laurent Lavoisier (1743–1794).

Georges Cuvier (1769–1832).

Ambroise Paré (1517–1590).



René Descartes (1596–1650).

René-Just Haüy (1743–1822).

Jean-Baptiste Lamarck (1744–1829)

Pierre-Simon Laplace (1749–1827)

André-Marie Ampère (1775–1836).

and of serving the needs of government. Actually the Academy of Sciences, in very much the same way as the Royal Society, grew out of regular meetings of scientists who gathered for informal discussions. It was also at that time, on January 5th 1665, that the first scientific journal made its appearance, the *Journal des savants*, preceding the *Philosophical Transactions* by three months, and the German *Acta Eruditorum* by seventeen years.

Colbert took another important step to promote science; he persuaded Louis XIV to grant financial awards to the most eminent scientists whether French or foreign. This system of prizes was later adopted by the Academy of Sciences and contributed largely to the furthering of scientific progress from the eighteenth century onwards. Again it was Colbert who, with a view to developing French navigation, was the prime mover in the creation of the Paris Observatory (1667–72) to which he brought the greatest astronomers of the day: the Dutchman Huyghens, the Dane Reomer, and the Italian Cassini (1625–1712) who settled permanently in France and founded a dynasty of illustrious French astronomers. Work of the first importance was accomplished there in the first few years. From Cassini's observations on the eclipses of Jupiter, Roemer deduced the speed of light. Huyghens did a large part of his pioneering work whilst attached to the observatory. Picard (1620–82) calculated the size of the earth and it was his figure which Newton used in determining the force of gravity. Indeed in its early years the Observatory was by far the most productive and the most important scientific institution in the world. But it also became at that time France's only title to scientific grandeur. For in the last quarter of the seventeenth century there was a distinct decline in French science, and not until the second quarter of the eighteenth century did the tide turn again.

Abuse of Cartesianism

There were several reasons for this decline. On the intellectual side the chief blame must be borne by the exaggerated and distorted Cartesianism which about that time took a firm hold on French thought. Out of excessive admiration for reason grew a contempt for observation and experimentation which would have shocked Descartes himself. Whilst Newton was publishing his *Principia* (1687), the fashion in France consisted of writing voluminous dissertations on science produced by reasoning alone. It may be mentioned that it was in the course of this process that popular science writing was born with Fontenelle (1657–1757) as its originator and its most brilliant exponent.* In the first decades of the eighteenth century, whilst English and German scientists were working on Newtonian physics and on Newton's and Leibniz's differential calculus, French scientists were still immersed in the study of analytical geometry and in the theory of vortices, one of Descartes's less fortunate ideas.

On the material side probably the most important factor hampering scientific development was the revival of religious persecution under Louis XIV. The repeal of the Edict of Nantes in 1685 drove into exile many of France's best intellects both native and imported. Denis Papin (1647–1714), the collaborator of Huyghens and one of the first precursors of the steam engine had to leave for England where he became a Fellow of the Royal Society and worked with Boyle. Roemer was also driven into exile, while Leibniz, but for his Protestantism, would have been able to take up his abode in France.

At the same time, in 1683, the death occurred of Colbert, a major loss to French science. His successor, Louvois, took no interest in science and even prevented Huyghens from returning to France. Finally, the universities were still in the grip of routine and could not stand comparison with those of England and Germany as far as the study of science was concerned. As for the *Collège Royal*, the *Jardin du Roi* and the Academy of Sciences—which had been created expressly to counteract the paralysing influence of the universities—they were hardly adequate to cope with the needs of an age in which science was becoming too complicated to be carried on by dilettanti, however brilliant.

In the circumstances it is not surprising that during the period in which England produced a Newton, Germany a Leibniz, and Holland a Huyghens, no comparable name enriched French science. It was only in the second quarter of the eighteenth century, when Newton's ideas began to triumph in France as elsewhere, and when experimentation was restored to its proper place, that France again came to the fore.

The Newtonian Impetus

In justice it should be said that once Newton's ideas gained a firm hold, it was France which, more than any other country, contributed to their verification and their development. As Laplace said: "If England had the privilege of giving birth to the discovery of gravitation, it is mainly to French geometricians and to the prizes awarded by the Academy of Science that are due the numerous developments of that discovery and the revolution it produced in astronomy".

Newton's work was made known in France mainly by the writings of Maupertuis (1698–1759), who is best known by his principle of least action, in 1733. It was carried on by Clairaut and d'Alembert who, together with the Swiss Euler, were the greatest mathematicians of the first half of the eighteenth century. Alexis Clairaut (1713–1765) was the precocious child who at the age of 12 read to the Academy of Sciences a paper in which he made abundant use of infinitesimal calculus. He entered the Academy at 18 and in the course of his career made major contributions to differential and integral calculus, to the theory of the shape of the earth, to the so-called problem of three bodies, etc. Jean le Rond d'Alembert (1717–1783), a foundling, also made major contributions to algebra, calculus and mechanics. He was the author of the principle which bears his name and still remains one of the fundamental concepts of dynamics, and of a treatise on dynamics which is one of the most important works on the subject. He was also one of the founders of hydrodynamics. His and Clairaut's work led to the full confirmation of the Newtonian law.

Another name stands out in this period, that of René Antoine de Réaumur (1683–1757), whose work has stood

* His *Entretiens sur la pluralité des mondes* (1686) was the first exposition of popular science and became the model for its successors.

the test of time better than that of most of his contemporaries. As physicist he perfected the thermometer and invented several industrial processes. But his name has gone down as that of a naturalist—in the opinion of T. H. Huxley he was the greatest naturalist between Aristotle and Darwin. He was one of the originators of biological experimentation and the founder of ecology. His most important work is his *History of Insects*. He was also instrumental in bringing about the discovery of parthenogenesis by the Genevan, Charles Bonnet, in 1740.

This was the time when the first experiments were being made on electricity. In this connexion, Cisternay du Fay (1698–1739), administrator of the *Jardin du Roi*, first established the distinction between conductors and insulators, and that between positive and negative electricity.

In this mid-eighteenth century period science began to exert a profound influence on society in all civilised countries, and this in turn reacted on the development of science. Nowhere was this process more deeply felt than in France. French society at that time was one of the most cultured and most brilliant that has ever existed, and it took a lively interest in all things pertaining to science. Whilst the Marquise de Châtelet was translating Newton's *Principia*, the élite of Parisian society flocked to the *Collège de Navarre* where the Abbé Nollet lectured on physics, or to the *Jardin du Roi* where Rouelle lectured on chemistry. Buffon's *Natural History*, the first volume of which appeared in mid-century, had more success amongst the general public than most popular novels. French Enlightenment, having to a large extent sprung from the tremendous increase of scientific knowledge, was naturally characterised by a general enthusiasm for science. The great Encyclopedia (*Dictionnaire raisonné des sciences, des arts et des métiers*), started in 1751, was a gigantic attempt to unify and popularise the achievements of the new science. It was edited by d'Alembert and Diderot, and d'Alembert's *Discours préliminaire* was a most remarkable synthesis of human knowledge of the time.

The degree of prestige French science had regained by the middle of the century can be judged from the fact that when Frederick the Great wished to enhance the standing of the Berlin Academy (founded in 1700 under the inspiration of Leibniz on the model of that of Paris) it was to France that he turned in search of talent. Maupertuis was called to the presidency of the Berlin Academy, and when he left this position twelve years later it was d'Alembert who was offered the succession. Actually he declined, preferring merely to act in an advisory capacity from Paris. On his death he was succeeded by Condorcet.

It was also in the middle of the century that the first technical schools made their appearance in France. For Newtonian science called for a good scientific education, above all for a thorough grounding in mathematics; as the Universities were unable to provide it, special schools were required. In this way were created the *Ecole des Mines* and the *Ecole des Ponts et Chaussées* in 1747, the *Ecole du Génie* at Mézières in 1750, the *Ecole militaire* in Paris in 1752. They were to produce a rich harvest of scientists of the highest calibre during the second part of the eighteenth century. On the whole, the French monarchy had a far greater appreciation of the needs of science than later generations have given them credit for. The second half of the eighteenth century saw an extraordinary rise of science in France, a rise which rapidly brought her into the lead in all important branches of natural knowledge.

In the *exact sciences*, the whole of this period is dominated by three great figures: Lagrange, Laplace and Monge.

Joseph Louis Lagrange (1738–1813) was born in Turin of French stock and later became a naturalised Frenchman. He recreated the calculus of variations when he was 19, and later systematised the subject of differential equations and reduced the theory of mechanics to general formulae. His sweeping generalisations could often be used in physical problems. His *Mécanique analytique* is a masterpiece of scientific literature, in which the whole of mechanics is founded on the conservation of energy in the form of the principles of virtual velocities and least action. Lagrange did more than anyone except Laplace to develop the Newtonian system.

Pierre Simon Laplace (1749–1827), son of a Normandy farmer, was one of the greatest intellects in the history of science. The bulk of his work was devoted to two problems, that of celestial mechanics and that of the calculus of probability. He completed Newton's work most brilliantly, showing in particular that Newton's fear that the solar system would become deranged with time by its own action was unwarranted. In his *Mécanique céleste* he translated the substance of Newton's *Principia* into terms of the infinitesimal calculus, and completed it in many respects. In another of his works, the *Analytical Theory of Probabilities*, he built the edifice of the calculus of probability. Politically an opportunist of the first rank (in marked contrast to Lagrange), he transferred his allegiance successively from the King to the Revolution, then to Napoleon, and then again to the restored monarchy—and ended as a Marquis of the Restoration.

Gaspard Monge (1746–1818), son of a hawker, from being a student at the *Ecole du Génie*, became, overnight, professor at the same institution as a result of his invention of descriptive geometry. He threw himself heart and soul into the Revolution and in the process became an intimate friend of Bonaparte to whom he remained faithful until his death. He was the real founder of the *Ecole Polytechnique*, accompanied Bonaparte to Egypt, and, because of his fidelity, was one of the first victims of the Restoration. But descriptive geometry remains today as he created it.

Amongst other figures of that time mention should be made of the mathematician Legendre, the astronomers La Caille, Méchain, Lelande, Delambre, and Cassini III, though none of these can rank with Lagrange, Laplace and Monge.

The second half of the eighteenth century also saw the birth of modern chemistry with Lavoisier as its founder.

Antoine Laurent Lavoisier (1743–94) was an outsider to science, one of that élite which flocked to the lectures of Rouelle at the *Jardin du Roi*, where he developed the taste for chemistry, or rather for what then passed for chemistry—a kind of medieval alchemy still based on earth, water, air and fire as the four fundamental elements. This he replaced by a set of doctrines founded on rigorous experimentation and on the evidence of facts. By his correct explanation of the part played by oxygen in combustion, he overthrew the phlogiston theory. He established once and for all the conception of chemical elements

in the modern sense—he himself was able to recognise correctly twenty-three of them. Using the balance as the basic instrument of chemistry, he showed that nothing is lost and nothing gained in chemical actions and natural transformations. His principle of conservation of matter is one of the most fundamental concepts of modern science.

But Lavoisier's pioneering work was not confined to chemistry alone. His fundamental discovery that respiration was simply a slow combustion within the body was the starting point of general physiology. This fact established, Lavoisier explained the calorific function of perspiration and digestion, thus laying the foundations of biological energetics. But to study these phenomena he had to measure quantitatively animal heat. And so he evolved, in collaboration with Laplace, a new technique for measuring heat, calorimetry, which opened up a new and important field of physics. All this tremendous work was accomplished between his thirtieth and forty-sixth year in face of the unanimous opposition of all the scientists, including Priestley, Cavendish and Scheele. But when his *Traité de chimie* was published in 1789 it swept aside the opposition and revealed the new realm of modern chemistry.

But Lavoisier was also a member of the financial oligarchy of the *Fermiers Généraux* who were the tax collectors for the monarchy. And although he had always carried out his function with the utmost honesty and with a high sense of public duty, he could not escape the fury of the Terror. His execution is perhaps the worst stain on the Revolution and one of the greatest dramas in the history of science.

In *physics* the dominating feature of that period is the development of electricity and magnetism, and the dominating figure in this field is Charles Augustin de Coulomb (1736–1806), also a product of the *Ecole du Génie*. He re-invented the torsion balance (first constructed by the Englishman Mitchell in 1750), and by its use was able to prove that Newton's law of inverse squares held good for electric and magnetic attraction and repulsion. He thus gave birth to two new branches of science which, until then, had been no more than a mere collection of facts and vague statements: electrostatics and magnetism. Besides this he also studied friction and torsion and established their laws.

In the field of *natural sciences* the most conspicuous figure of this pre-revolutionary era was undoubtedly Georges Louis Leclerc de Buffon (1707–88), a mathematician who at the age of 32 became by accident administrator of the *Jardin du Roi* and turned to natural science through force of circumstances and sense of duty. He made no discovery of importance but he wrote (with the assistance of Lacépède, Daucenton and others) a monumental *Natural History* in 44 volumes.* The faults of this work are today very apparent; but so also are its merits. With brilliant intuition Buffon was able to piece together many ideas and concepts which were to form the basis of the zoological philosophy of the nineteenth century. He first attempted a comprehensive explanation of the world in terms of natural laws and scientific reasoning. He was a precursor of evolutionism, and though he estimated at only 75,000 years the age of the Earth, he was the first to break away from the 6,000 years of biblical tradition and to have a clear view of the immensity of geological ages. The all-powerful Sorbonne denounced fourteen of the propositions contained in the first volume of his 'History', and for the sake of peace Buffon made a formal recantation but continued along the lines of his original thought.

Contemporary with Buffon in the *Jardin du Roi* were the Jussieu family (Bernard, his brother Antoine, and his nephew Antoine Laurent) who were the great botanists of their time and are chiefly known for their system of classification of plants which was a great improvement upon that of Linnaeus.

This same period saw the birth of mineralogy as a modern science. This was due to the development of crystallography, the creator of which was the Abbé René Just Haüy (1743–1822) who did his work so completely that only details were left for his successors to provide.

The second half of the eighteenth century also nurtured the beginnings of the Industrial Revolution. Here again France was well to the fore. In 1769 Cugnot constructed the first automobile, a car propelled by steam, which could do two and a half miles per hour and worked a quarter of an hour at a time. The Marquis Jouffroy d'Abbans invented the first paddle-steamer which, in 1776, travelled backwards and forwards on the river Doubs. Fulton later acknowledged the debt he owed to this Frenchman. And on June 5, 1783, the Montgolfier brothers launched the first balloon by inflating a linen cover with hot air. It reached a height of 6,000 feet. A few weeks later the physicist Charles used a silk cover inflated with hydrogen. The first ascent was made on November 21, 1783, by Pilâtre de Rozier. In the same year a young Army officer, the mathematician Jean Baptiste Meusnier (1754–93) read before the Academy a paper containing all the modern theory of aeronautics of the 'lighter than air' machines. He was a pupil of Monge who considered him the most extraordinary brain he had ever met.

But the most important development in applied science was the introduction of the metric system. The idea first gained root at the beginning of the eighteenth century but the preparatory work involved in fixing the units did not start until 1791. It was carried out under the auspices of the Academy of Sciences, and all the great scientists of the period, including Lagrange, Laplace, Monge, Coulomb and Lavoisier, took part in it. On June 22, 1799, the legislative assemblies adopted the metre and the kilogramme as units of the new system.

Effects of the Revolution

In the second half of the eighteenth century French civilisation held sway over Europe and science was a cornerstone in that civilisation. The Revolution itself, though it brought a temporary chaos, in the long run proved a strong stimulant. In the early days, no doubt, the outlook was gloomy. Lavoisier and some lesser lights were swept away by the Terror; while all the scientific institutions automatically came under suspicion, simply because they were institutions. The Academy of Sciences was suppressed in 1793, and so were the universities—though these, being still in the grip of theology, were no great loss to science. However, the Terror was of brief duration. Reaction soon set in, and in 1795 the Academy was re-established as part of the *Institut de*

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* Thirty-six volumes appeared during his lifetime, eight were written after his death by his assistants, mainly by Lacépède.

Living Cells under the Microscope

A. HUGHES, M.A., Ph.D.

In the history of science, there is seldom a simple relationship between the progress of discovery and the technical advances in method and apparatus which make possible the particular field of research. Often an initial technical development at once leads to new observations, but the subsequent steps in the improvement of the apparatus, and in the discoveries made thereby, may be linked in a more complex manner than as immediate cause and effect.

The study of the structure of animals and plants by means of the compound microscope is an instance of this generalisation. The microscope of Robert Hooke, illustrated in the *Micrographia* (1667) enabled him to describe the 'texture of cork', and give the first account of the cellular structure of plant tissue. Soon afterwards, Malpighi and Grew extended Hooke's work on plant structure, but further general advance in this field had to wait for the early part of the nineteenth century.

This period is of outstanding importance in this field for two reasons: first, for the application of achromatism to the microscope objective, eliminating colours due to refraction by the lenses; secondly, for the recognition of the fact that animals and plants are alike made up of cells, which contain a structure of basic importance, the nucleus.

How close is the connexion between these two separate advances in microscopy? The facts are as follows. Objectives with some degree of correction of the errors of single lenses were made by various opticians from 1800 onwards, and even earlier; but it was not until 1830 that J. J. Lister, the father of Lord Lister, published his paper on the two aplanatic foci of a lens system—an aplanatic lens system gives an image free from spherical aberration. This made possible an objective comparable with modern standards. Soon afterwards, in November 1831, Robert Brown read a paper on the organs and mode of fertilisation in Orchids and Asclepiads before the Linnean Society, in which he describes the nucleus of the epidermal cells of the leaves of orchids, and in the cells of the staminal hairs of Tradescantia.

Brown knew Lister well, and had lent him in 1829 a set of German lenses used in various combinations, which Lister employed in his work on the aplanatic foci. It is probable that Brown was using objectives of some degree of correction in his investigations of plant tissues at that time. Yet it was not until the end of the 1830's that English makers, such as Ross and Powell, were manufacturing objectives constructed on Lister's principles, of more than low magnification, with the increased aperture thus made possible. So, it is improbable that Schleiden and Swann in 1838–40 were using the full possibilities of achromatic objectives in their work on which the cell-theory of plant and animal structure is generally considered to be founded. In fact, they would not have been able to work with objectives of full aperture even if such had been available.

At that period, tissues were studied in a fresh condition, in thin sections or scrapings, for there were then none of the methods of fixing and staining on which most of the later study of histology has been based. Now, as everyone knows who has looked at fresh living tissues with an ordinary microscope, it is necessary to close the substage iris, in order to see anything at all in a transparent, unstained object. The pre-Listerian objectives of low aperture were thus adequate for the microscopy of the 1830's, and not until the study of stained preparations in the second half of the century was it possible in this field of study to take full advantage of the objectives, which had been designed by Lister 30 years or so previously.

Once both branches of technique, optical and biological, had been developed, progress was rapid. Virchow in 1858 maintained the cells always arise from other cells, a fact previously obscured by the erroneous account of cell formation given by Schleiden and Swann. By then, Remak had stated that division of the cell nucleus always precedes cell division, but had given an incorrect account of the process. The actual details in the sequence of events in the indirect division of the nucleus, common to all higher plants and animals, were worked out in the decade following Schneider's work on flat-worms in 1873. This fundamental event in cellular biology is now know as 'mitosis', the name given to it in 1882 by Flemming, the most distinguished single figure in this field of research.

Flemming studied nuclear division in fixed and stained preparations, and also in the living cells of the same material. This is one of the really outstanding features of his work. The limitations of the ordinary microscope in observing unstained living material, however, are such that subsequent progress in this field has inevitably been very largely based on the study of fixed and stained cells, and the techniques of such study have been developed to a great degree of fineness and accuracy, in which the cytologist has been long accustomed to working at the very limits of resolution of the visual microscope.

Tissue Culture

Progress in the cytological study of living material since Flemming's day there has certainly been, but on a more limited scale. The efforts of a series of workers have increased the range of dividing cells which may be studied in life; Joly for instance, in 1902 observed the division of the mother-cells of the blood corpuscles of newts, but the most significant step in this direction was taken by Ross Harrison in 1904, when he laid the foundations of that branch of biological technique which we call 'tissue culture'.

Harrison took a fragment of nervous tissue from a frog, and placed it on a cover slip in a drop of frog lymph. The cover slip was sealed over a glass slide, forming a 'hanging-drop' preparation, such as Koch first used in bacteriology in the 1880's. This 'explanted' frog tissue survived for several days in the clotted lymph, into which the living cells began to grow and send out processes and nerve fibres, in a manner comparable to that which happens in the fibrin clot of a wound. The outgrowth from this tissue culture thus formed a thin sheet of living cells

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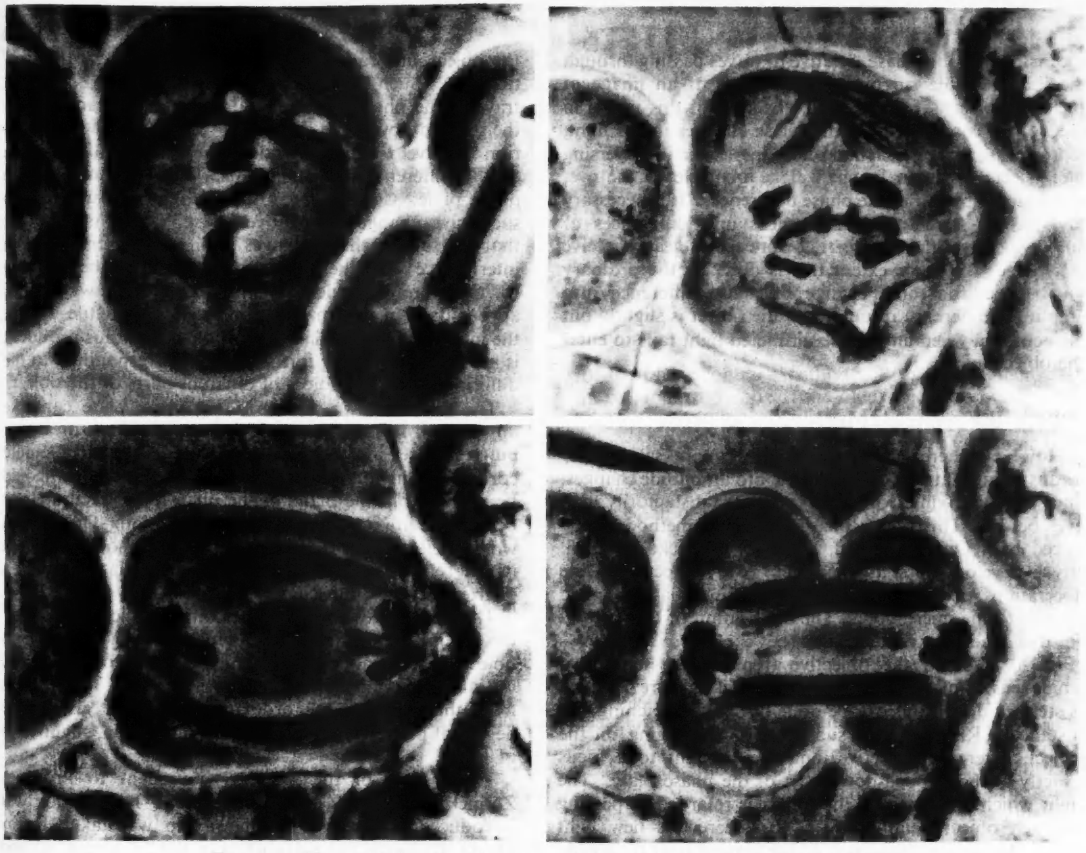


FIGS. 1–4. These stills from the phase contrast film made by Dr. Kurt Michel show four stages in the division of a sperm-mother cell of a grasshopper. From this cell four ripe sperms would be formed by two successive divisions; the first, illustrated here, being the reduction division or meiosis. FIG. 1. The chromosomes are arranged in an equatorial plate; this stage is called metaphase. FIGS. 2–3. In the next stage (anaphase) the chromosomes are separated into two groups. FIG. 4. Telophase, the stage where cell division follows nuclear division. × 1200 approximately. (*Courtesy of Kodak Ltd.*)

exquisitely accessible to microscopical examination. The very great possibilities of this procedure as a technique in the experimental study of living cells were soon realised, and the method was developed by a number of workers, chiefly at first in America. It was soon observed that the outgrowth of cells from the explant into a surrounding nutrient medium was in part an outward migration of cells and partly a new growth of cells by mitotic division; provided that the medium had 'growth-promoting' properties, such as are conferred by the expressed juice from an embryo, where rapid cell division is generally in progress. Thus the tissue culture method provided a means of studying the whole life cycle of a cell, from one division to the next.

The value of tissue culture extends of course much beyond this circumstance into regions of experiment in many fields of biological study. Yet to observe the changes which a living cell undergoes in dividing into two daughter-cells is always one of the most fascinating experiences possible for a microscopist. Nor is the study of cellular events in living cells of a tissue culture exhausted by direct observation. Serial photographs of a field of cells can be made at fixed intervals on ciné-film, and the resulting record of cellular growth and change projected on to a screen, so that the time axis can be compressed at will, and a new insight obtained into events which happen too slowly for their full appreciation by direct observation.

This method of speeded-up motion is, of course, well known. Probably it was first applied to the study of cells in division in 1905, by Dr. Comandon, about whose subsequent and highly distinguished work in this field an article recently appeared in DISCOVERY (October 1946, pp. 302–7). In this country, the late Dr. R. G. Canti's outstanding work on the ciné-micrography of tissue cultures was begun in the late 1920's.

Up till recently, the study and recording of the movements and activities of living cells, exciting and important as it has been, has suffered from the inherent limitations of the ordinary microscope in viewing transparent objects. The detail of such an object as a living cell, consists of structures differing in refractive index from that of their surroundings. A light wave in traversing such a refractile

spot is retarded in phase, relative to waves passing through the less refractile surrounding material. If an image of such an object is formed by a lens system, this image in theory will consist only of the phase changes in the light, reproducing those which had been experienced in traversing the object. Such an image will be invisible to the eye, which does not appreciate phase differences. It is necessary to translate these phase differences into differences of *amplitude*, or of *light intensity*, before the eye can perceive the image. To some extent this is done by the ordinary microscope, for some change of phase difference into amplitude difference results when the object is slightly out of focus and when any of the diffracted light fails to enter the objective.

'Phase-difference' Method

However, there is now available a more satisfactory means of translating phase changes into amplitude changes, and so of observing living cells far more satisfactorily than ever before. This is the 'phase-difference' method, introduced by a Dutch optician, Professor Zernicke, in 1933. It was developed first as a means of ready detection of the aberrations of telescope mirrors, and was later applied by him to the microscope. The application of the method to the latter instrument may be explained as follows (Fig. 5). Behind the objective (represented here by a single lens) is placed a parallel plate of glass, part of which is stepped down (this can be done by selective etching, for instance). Rays of light such as (*a*), converging on the object, enter the objective, and are brought to a focus exactly at the stepped-down part of the phase plate. The light which in traversing the object is retarded in passing through object detail, may be considered as new light waves, lagging in phase behind the general light traversing

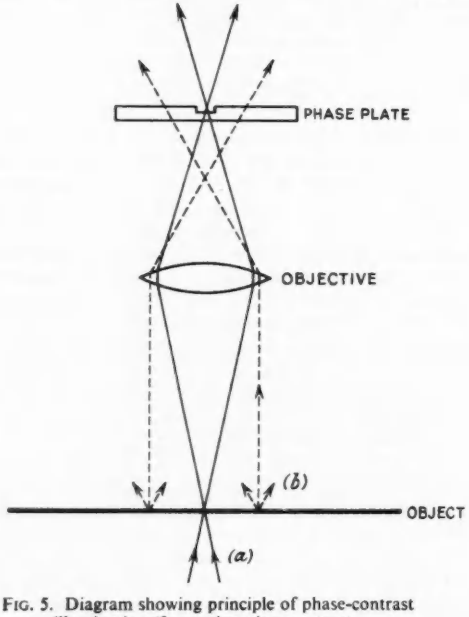


FIG. 5. Diagram showing principle of phase-contrast illumination (for explanation see text).

the object, and radiating out from the object in all directions (*b*). Such of this light as enters the objective will traverse the phase plate generally elsewhere than through the stepped-down area, and so will suffer a further retardation relative to the general beam of light (*a*), because of the difference in path between the two areas of the phase plate. Component (*b*) of the light has suffered two successive changes in relative phase, and it is arranged that the sum of these changes shall be sufficient to cause interference with the general component of the light (*a*) for the more refractile portions of the object, which thus appear dark in the image. For the less refractile details, the interference is partial. The whole image thus produced is a picture in varying tones of grey, corresponding to the differing refractive indices of different parts of the object.

The stepped-down portion of the phase plate can take any desired form. It may either be a diameter, or a ring, but it is necessary to arrange that the light source should correspond in form, and an image of the source should be projected in the plane of the phase plate accurately to occupy the area of the stepped-down region. The method works well in white light, and can tolerate some variation in the relative retardation of the phase plate, though a quarter wave-length of green light is usually chosen.

The advantages of the phase-contrast microscope over the ordinary form for the observation of transparent objects is not only the heightened contrast of the image, but also in its greater sharpness of detail.* This follows from the fact that the ordinary microscope gives some degree of phase contrast when, but only when, slightly out of focus.

The history of the method subsequent to Professor Zernicke's discovery can soon be told. The method was introduced to English opticians, and was taken up by Dr. C. R. Burch, who described in 1942 a simple method by means of which phase-difference microscopy could be applied to the ordinary objective. The first commercial form of the instrument was made by Zeiss during the war; a similar phase-contrast outfit is now being manufactured in this country by Messrs. Cook, Troughton and Simms, of York.

The literature of phase-contrast microscopy now includes upwards of a dozen papers, but the biological application of the method is only just beginning. The honour of the first use of phase contrast in recording cellular processes belongs to Dr. Kurt Michel, who at the Zeiss works at Jena during the war produced a valuable film of the development of sperm in a grasshopper, which is of particular importance in showing the process of reduction division, or meiosis, characteristic of the maturation of the germ cells of higher animals and plants (Figs. 1–4).

The present writer has been using phase-contrast objectives for ciné-micrography of tissue cultures for the

* It would not be true to claim that critical conditions are now achieved for the first time in the microscopy of transparent objects, because the full aperture of an objective can also be used in the dark-field method; where on a black background, the refractile object detail appears bright, lit by an oblique beam which does not enter the objective. Dark-field microscopy, however, is of limited application to living cells other than bacteria, because a general glare results from any but the thinnest object, and the light intensities used are so great that observation is only possible for a short time. These disadvantages do not apply to phase-contrast microscopy.

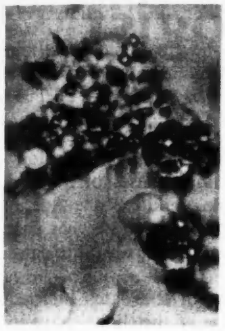


FIG. 6 (*left*). Macropnage of an embryo chick lung photographed by phase contrast. The veil-like undulating membrance surrounding the cell is seen. A macrophage is a type of wandering cell which can engulf small particles or foreign bodies such as bacteria. Magnification, 800 times. (*From a culture prepared by Dr. H. B. Fell.*)

FIG. 7. Cells in a tissue culture, by phase contrast, in the stage between divisions. This lasts at least twelve hours. The membrane limiting the nucleus can be seen. Outside the nucleus are seen lipoid granules, and the thread-like structures known as mitochondria. Magnification, 800 times. (*Culture prepared by Mr. L. J. King.*)

past few months, and (Figs. 6 and 7) are here reproduced from recent films made in collaboration with my colleagues. Fig. 6 is of a macrophage or wandering cell, from the lung of a chick embryo. These cells are phagocytic, that is, they engulf particles of suitable size by means of the elaborate undulating membrane which surrounds the cell. The full extent and activity of this membrane was not realised until the phase-contrast picture of its motion was seen. Fig. 7 represents chick tissue-culture cells between divisions. The nucleus can be seen, sharply outlined, containing the refractile nucleoli. In the cytoplasm surrounding the nucleus, small fat granules are shown as black dots; and also the fine filaments, known as mitochondria, can be seen. The resolution of these structures is a test of the performance of the microscope.

The influence of phase-contrast microscopy on the future development of cellular biology and indeed of other possible fields of application, is for the future to show. At the moment, the prospects for cytological work on living material seem very bright; there is the incentive of the problems of the mitotic process, still some way from solution, in spite of the fact that biologists have been acquainted with the outlines of the process for more than seventy years. It is improbable, however, that the introduction of the phase-contrast method will mark a sudden change in research in this field; the older microscopy has already yielded important information, as in the hands of Karl Belar. Probably the most valuable result will come from a combined use with other special microscopical techniques applicable to living cells. The polarising microscope, which can provide information on structure at the molecular level is now so sensitive that it can be used on the single undifferentiated cell; and by photomicrography of living material in the ultra-violet it should be possible to learn something of the distribution of biologically important material which has characteristic absorption spectra in these wavelengths.

At any rate, it can be said that the methods of microscopy are being extended; that opticians and biologists are learning of the problems and possibilities in each others' fields, and that in these respects, this phase of development recalls the earlier era of advance in microscopy during the 1830's. At that time, the maker of an experimental microscope more than once used it to discover fundamental facts in biology with its aid. We are returning towards that position, after an intervening era when the biologist seldom looked beyond the standard instruments of the manufacturer's catalogues.

FRENCH SCIENCE—PAST AND PRESENT—*Continued from p. 269*

France, with most of the old Academicians in its ranks. The great majority of them had actually been right from the beginning sincere supporters of the ideas of the Revolution. The *Jardin du Roi* conveniently changed itself into the *Muséum National d'Histoire Naturelle* by which name it is still known today; and the *Collège Royal* became the *Collège de France*. But the work of the Convention went further than renaming institutions of the *ancien régime*. It set about creating new ones: the *Bureau des Longitudes* which was to publish yearly data on astronomy, meteorology, physics, etc.; the *Conservatoire des Arts et Métiers* to promote the progress of industry: the *Ecole Normale* which was to train teachers for secondary schools; and above all the *Ecole Polytechnique* which right from the start became the breeding-ground, unique in its way, of French men of science. By its very severe entrance examination, particularly in mathematics, it sifted the best scientific material available. And the vast majority of the great French mathematicians and physicists of the early nineteenth century—Cauchy, Poisson, Fresnel, Ampère, Sadi Carnot, Gay-Lussac—were intimately associated with the *Ecole Polytechnique*, either as students, or as professors, or both. The great figures of chemistry and biology were to be found at the *Muséum* and, increasingly, at the *Collège de France* (Balard, Thénard, Lamarck, Cuvier, Geoffroy Saint-Hilaire, Laënnec).

The creation of the *Ecole Polytechnique* and the *Ecole Normale* brought with it another innovation: for the first time, there appeared the type of the professor-scientist, drawing his income from teaching, a type that was to displace completely the independent scientist and to become generally accepted everywhere.

On the whole, the Revolution infused new life into French science. The first generation of the nineteenth century saw a blossoming of science in France which has rarely been equalled anywhere. While the older crop was still yielding a splendid harvest, a new one no less splendid and even more prolific was coming to fruition. The period between 1800 and 1830 is rightly called the Golden Age of French science.

(*To be concluded*)

Time and the Anthropologist

PROFESSOR F. E. ZEUNER

STUDENTS of early man are notoriously eager to make use of any time-scale offered to them, and more than once eminent authorities have presented chronologies of human evolution which, so far as the time-scale was concerned, were based on sheer guess-work. It is thus only natural that other workers hold sceptical views on the subject of chronology and regard all time-scales with suspicion. A few words about the reliability of time-scales used in the present article are therefore hardly out of place.

All four geochronological methods (described in an article in DISCOVERY in April 1946) are concerned in human evolution. Of tree-ring analysis little need be said, since it can be applied to the dating of only about 1500 years of the past—and this in a very restricted area of the south-western United States. The dating of the ancient pueblos (village sites of pre-Columbian Indians) of Arizona and New Mexico is likely to be correct with a margin of a few decades.

Varve analysis—the counting of annual layers formed in glacial lakes—is centred on Scandinavia or, more precisely, on central Sweden. The varve countings for this area appear to be reliable within a margin of a few hundred years. They extend back to about 8000 B.C. Earlier dates are highly uncertain and have come in for serious criticism. The application of the more reliable part of the varve record, however, meets with the difficulty that the evidence for early man which it is intended to date does not occur in the varved clays but in some other deposit, often a considerable distance away. The links used in connecting the two are ancient shore-lines, and the sequence of climatic phases as revealed by pollen-analysis. As to the former, dwelling sites on an ancient beach have in many cases been connected successfully with varve sections by tracing the coastline over great distances, especially in Finland. But where ancient coastlines cannot be traced without interruption, a factor of uncertainty enters the picture, since owing to the changes in altitude which Scandinavia has undergone, height above present sea-level is not a sufficient criterion. Recently this fact has introduced an awkward complication into the chronology of the time since the last Ice Age—the post-Glacial. Danish workers have found that the well-known Litorina Transgression, which inaugurated the present conditions in the Baltic, was not simple but possibly repeated (in Denmark at least) three—if not five—times. It is evident that this discovery will bring in its train a revision of the chronology of early man so far as it depends on the Litorina Transgression.

Pollen-analysis is concerned with the determination of fossil pollen grains preserved in deposits, mainly of peat, and their statistical evaluation. An idea is thus obtained of the type of vegetation existing at the time, and this may be interpreted in terms of climate. Pollen-analysis has established a sequence of climatic phases since the Last Glaciation. In recent years, considerable advances have been made in the study of the earlier of these phases, and much has been learned about a mild phase followed by another deterioration of the climate which occurred towards the end of Glacial times. The "Allerod Oscillation" provides an excellent datum-line in the relative chronology which is important in dating the final phases of the Old Stone Age and the beginning of the Middle Stone Age in temperate Europe. But the breakdown of the earlier part of de Geer's varve chronology has made the absolute dates for this phase rather uncertain.

At the moment, therefore, some of the dates inferred from varve counts by means of one of the 'links' have to be regarded with reserve. This leaves us with an extremely meagre calendar for the Middle Stone Age (Mesolithic) of Europe. Fortunately it has been possible to obtain dates from the historic calendar for the New Stone Age (Neolithic), the Bronze Age and the Iron Ages by studying objects which were either imported from the Mediterranean and Oriental areas into northern Europe or which are evidently copies of Mediterranean or Oriental prototypes. This historical method of dating prehistoric cultures in northern Europe has received special attention in Denmark. In Britain Professor V. Gordon Childe is the leading figure.

The astronomical method of dating the phases of the Ice Age in Europe and of its associated human remains and industries counts time in units of ten thousand years. Because it is often difficult to assign prehistoric industries to definite climatic phases and to separate climatic phases from each other, it is imperative that all figures proposed should be regarded as first approximations. It is probable, however, that the portions of the time-scale assigned to various industries are not utterly wrong. Even if one refuses to accept the astronomical method, one has to admit that a chronology based on Professor Penck's calculations for the duration of the Ice Age (as explained in the article in April, 1946) would not be radically different from that suggested by the astronomical method—though the details would of course be vaguer.

The least reliable dates are those for the later phases of the Old Stone Age, contemporary with the Last Glaciation. This is so partly because more accurate dating is required for these later and shorter industrial phases, and partly because their precise relation to the climatic phases required for these later and shorter industrial phases, and of the Last Glaciation is incompletely known.

Finally, the radioactivity method provides dates in millions of years for the pre-human stages of Man's ancestral line. The geological period in question is the Tertiary, which cannot yet be said to be covered by a sufficient number of reliable determinations. Its total duration is estimated at 60 million years by some authors and at 70 million by others; the durations given for the subdivisions of the Tertiary are still arbitrary. Nevertheless we are likely to be right in saying that the Miocene, for instance, lies within the *later* part of the Tertiary—and this is confirmed by radioactivity determinations which suggest that the Miocene occurred between 10 and 30 million years ago.

Similarly, the Eocene is located near the 50 million mark of the time-scale, but the limits given to this epoch on tables are still based on palæontological estimates of

duration rather than on evidence derived from radio-activity. Even though the figures used in tables and diagrams are bound to be inaccurate, they are no longer guesses but considered estimates.

After this critical summary of some of the difficulties of geochronology, it might appear almost a waste of printer's ink to discuss human evolution in the light of absolute time. But it must not be forgotten that, though there are difficulties, inaccuracies and mistakes, the methods used are basically sound. Some of them are checked by independent estimates based, for instance, on changes in the fauna (Sir Charles Lyell first used these in the middle of the last century), rates of sedimentation in lakes and oceans, and so forth. I think we are safe in assuming that the order of magnitude of the figures appearing in our time-scales is approximately correct. It is hoped that the reader, having read this introduction, will appreciate that '250 thousand' years may well have a margin of 50 thousand on either side, or '30 million' years a margin of as much as 10 million. Even so, the time-scales are veritable eye-openers, providing us with a measure for changing rates of evolution and suggesting interesting conclusions. I hope, however, that I have succeeded in convincing the reader that time-scales are not accurate enough to be accepted as scientific gospel, and that they should not be used for interpolations.

Time-scale in years	*Period*	*Climatic phase*	*Man and his ancestors*
15,000	Holocene	Postglacial	*Homo sapiens*
115,000	Upper Pleistocene	Last Glaciation	Neanderthal Man
150,000		Last Interglacial	?Keilor
	Middle Pleistocene	Penultimate Glaciation	
250,000		Great Interglacial	Swanscombe Man, ?Steinheim Man
	Lower Pleistocene	Ante-penultimate Glaciation	
500,000		Ante-penultimate Interglacial	*Pithecanthropus, Sinanthropus*
		Early Glaciation	
600,000	Pliocene	Villafranchian	*Australopithecus* (age conjectural) *Dryopithecus*
c. 15 million	Miocene		*Proconsul, Dryopithecus*

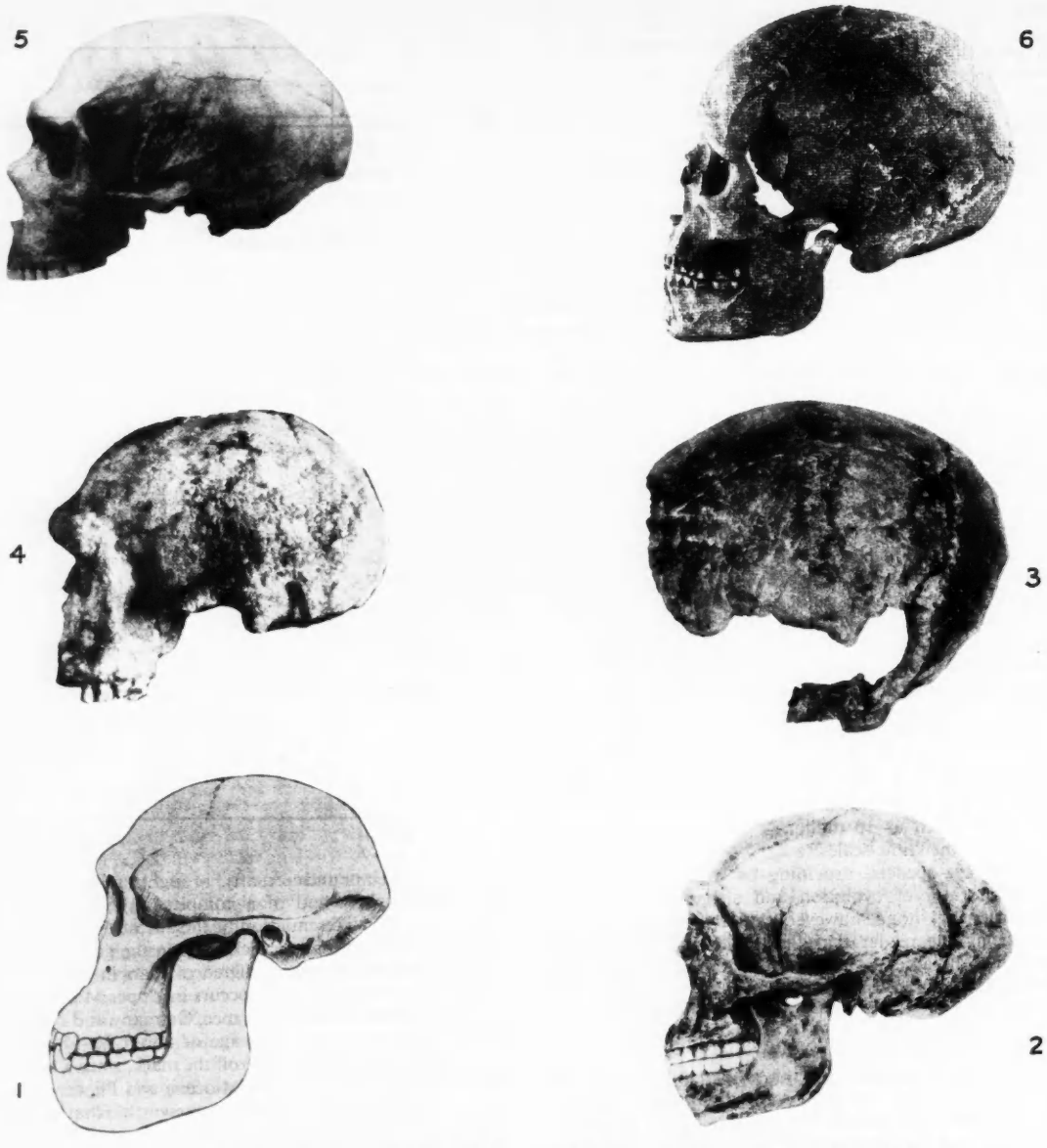
TABLE 1

Human Evolution

In an earlier number of DISCOVERY (April 1945) Professor W. E. Le Gros Clark of Oxford University described some of the oldest human fossils, which were discovered in deposits of early Pleistocene age in Java and in China. Though in the structure of the skull and size of the brain this *Pithecanthropus* group was almost half-way between modern man and apes, it must be regarded as definitely human; its limb bones prove that its posture was erect as in modern man, and its teeth are of the human type. It is possible to regard *Pithecanthropus* as the ancestral form from which the later types of man, Neanderthal man and *Homo sapiens*, developed in the course of the Pleistocene. On the other hand, it is evident that if man had reached the *Pithecanthropus* stage in the early Pleistocene, his evolution from ape-like ancestors must date back to the Upper Tertiary.

Apart perhaps from the lower Miocene ape, *Proconsul* (first described by Dr. A. T. Hopwood of the Natural History Museum and recently brought to the fore by Dr. Leakey's new find of a complete jaw; Fig. 8), the beginnings of a differentiation of the ancestral line leading from apes to man may be picked up in the genus *Dryopithecus* (see the tentative pedigree of man in the August 1946 issue of DISCOVERY). It occurs in Upper Miocene and Lower Pliocene deposits in France, Germany and northern India. If we assign to it an age of about 10–15 million years we are unlikely to be far off the mark, since a number of radioactivity estimates for Miocene and Pliocene rocks are fortunately available. It is noteworthy that the few limb-bones that have been assigned to *Dryopithecus* have suggested to Professor Le Gros Clark that these apes were already more distinctly adapted to walking in an erect position than any of the existing apes. Furthermore, the teeth of some species of the *Dryopithecus* group are so much like human teeth that it is not always easy to distinguish them. But in other characters, such as the shape of the jaw, these apes were still typically simian.

The thread of human evolution is again picked up in a number of South African fossils which we may collectively call the *Australopithecus* group (including *Paranthropus* and *Plesianthropus*.) The first specimen was described by Professor Raymond Dart of Witwatersrand University, and several others by Dr. R. Broom of Pretoria. These 'man-apes' from South Africa (Fig. 1) are in several respects more advanced towards man than any other known ape,



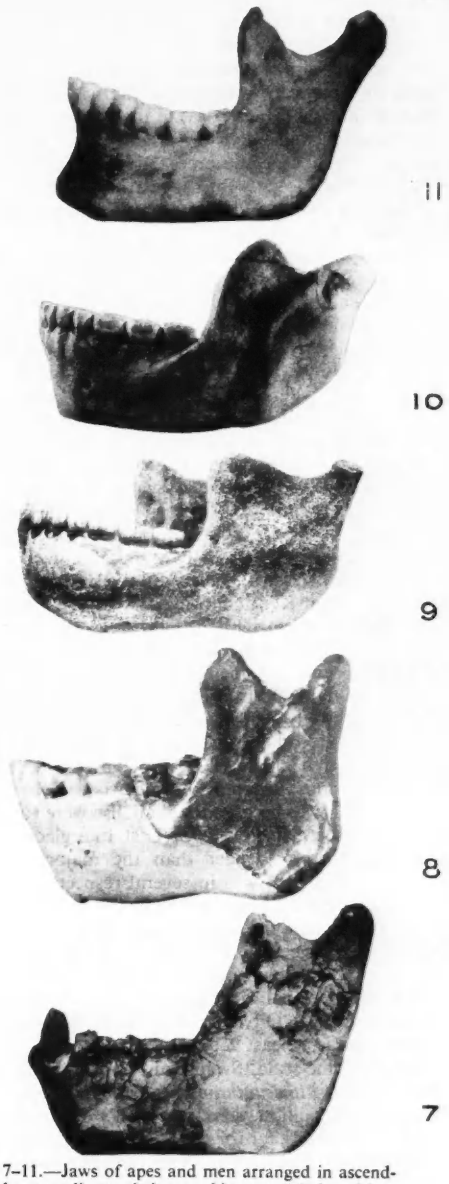
FIGS. 1–6.—Some skulls of fossil men and supposed ancestors of men, arranged in approximate order of age.
Bottom row: Lower Pleistocene and earlier. FIG. 1.–AUSTRALOPITHECUS from South Africa. Age unknown, but probably Pliocene rather than Pleistocene. FIG. 2.—SINANTHROPUS OF PEKIN MAN, from China. Age, about 500,000 million years (Lower Pleistocene). This represents the lowest human stage so far known, and is closely allied to Java Man.
Middle row: Middle Pleistocene Man. FIG. 3.—THE SWANSCOMBE FRAGMENT, from the Lower Thames Valley, near Gravesend. Age, about 250,000 million years. This fragment is regarded by some as evidence of a *Homo sapiens*—like Man in the Middle Pleistocene, but others point out that the primitive Neanderthalers, such as Steinheim Man, approach Swanscombe Man in the characters preserved. FIG. 4.—STEINHEIM MAN, from Middle or early Upper Pleistocene gravels at Steinheim, Württemberg. A primitive Neanderthal type which is in many respects reminiscent of Modern Man.
Top row: Upper Pleistocene Man. Two types are present, Neanderthal Man (Fig. 5) and Modern Man, *Homo sapiens* (Fig. 6). The former was the older type in Europe, but as he was replaced by immigrating *Homo sapiens*, the latter type must have been for a period contemporary with Neanderthal Man. FIG. 5.—NEANDERTHAL MAN from Le Chapelle-aux-Saints, France. Age: about 100,000 years ago, probably first phase of Last Glaciation. FIG. 6.—MODERN MAN from Combe Chapelle, France. Age, about 90,000 years ago, first mild phase of Last Glaciation.
Acknowledgments.—Fig. 1, reconstruction by Prof. W. E. Le Gros Clark, by permission of *Picture Post*. Fig. 2, reconstruction by Prof. F. Weidenreich, from *Palaeontologia Sinica*. Fig. 3, *Journal of Royal Anthropological Institute*, London. Figs. 4 & 6, after M. Boule. *Les Hommes Fossiles*. Fig. 5 is a photograph of a reconstruction.

particularly in the dentition and the palate, though the outline of the skull and the cast of the brain cavity show plainly that these fossils must still be regarded as true apes, and not primitive humans.

The age of the *Australopithecus* group has never been determined scientifically. Only the accompanying fauna of other mammalia has been collected with some care, though specimens from several neighbouring localities were grouped together in an attempt to obtain a larger and more representative fauna. For these reasons only a very tentative assessment of the age is possible. Originally these fossils were regarded as Pleistocene. But if the accompanying fauna is sorted out into species which were found associated with the skulls and those which came from other localities, one discovers that the Pleistocene elements were not closely associated with any of the skulls. On the contrary, the most complete fauna (that associated with *Australopithecus*) contains no modern species, but several extinct genera and thus appears to be decidedly old. Judging by European standards, where the rate of change in the specific constitution of fauna is known, one would regard *Australopithecus* as Pliocene. Quite recently a Pliocene age has been suggested for *Plesianthropus* on the strength of a hyena which, in Europe, is of Lower Pliocene age. But this specimen appears to come from 60 feet below the *Plesianthropus* level so that the latter may after all be substantially younger. Thus the impression one gains at the moment is that the *Australopithecus* group is more likely to be Pliocene than Pleistocene, antedating the earliest truly human remains of the *Pithecanthropus* group, but it would be useless to suggest an absolute age for them, except in so far as they are younger, perhaps much younger, than *Dryopithecus* of 10 million years ago, and probably older than *Pithecanthropus* of half a million years ago.

In discussing the *Pithecanthropus* group it is necessary to distinguish Java Man (*Pithecanthropus erectus*) and Pekin Man (*Sinanthropus pekinensis*), Fig. 2. They appear to be approximately of the same age, namely lower Pleistocene, but the evidence is different. The case of Pekin Man is the clearer of the two. The locality, the Chou-kou-tien cave near Pekin, lies in the temperate zone of the Palæarctic region, and a rich fauna has been described from the same cave by Dr. W. C. Pei and his colleagues. This fauna agrees well with that of the Cromer Forest Bed of eastern England and allied continental deposits which are all from the first or Antepenultimate Interglacial. For this reason one cannot but approve of Dr. Pei's placing Chou-kou-tien in the Lower Pleistocene.

The relative age of Java Man is much less certain. A palæontological comparison of the Trinil Fauna (of which *Pithecanthropus* is a member) with the Plio-Pleistocene succession of the Siwaliks in northern India suggests a lower Pleistocene or, at the latest, early middle Pleistocene age. The baby *Pithecanthropus*, which has been described as *Homo modjokertensis*, is earlier than the other *Pithecanthropus* material. But in comparing faunas of Java and north-west India it must not be forgotten that the distance is enormous both geographically (30–40 degrees of latitude) and climatically (across the equatorial belt), and that any correlation suggested contains a large factor of uncertainty. The result, however, is in accordance with that obtained for Pekin Man, though the range (from the



FIGS. 7–11.—Jaws of apes and men arranged in ascending order according to their resemblance to Modern Man.
FIG. 7.—*Proconsul*, a Miocene ape from East Africa with some human features.
FIG. 8.—*Sinanthropus*, the earliest human stage, apart from Piltdown Man whose age is doubtful.
FIG. 9.—The Heidelberg jaw, from Mauer near Heidelberg, West Germany; about 450,000 years old. It is on the whole Neanderthal-like, but much more massive.
FIG. 10.—Neanderthal Man, from La Chapelle-aux-Saints. In all earlier types there is no chin prominence; in Neanderthal Man this feature is indicated in some specimens, though often it is completely absent.
FIG. 11.—Modern Man, with chin prominent.
Figs. 7 & 11 by courtesy of Dr. L. S. B. Leakey.
Fig. 8 from Weidenreich, *Palaeontologia Sinica*. Fig. 9 from Boule, *Les Hommes Fossiles*.

final Pliocene to the beginning of the middle Pleistocene) is possibly a little longer.

In recent years a further complication has been introduced by American workers who find it more convenient, when dealing with East Asia, to include in the Pleistocene the 'Villafranchian' division of the Pliocene. Thus, our 'Lower' Pleistocene becomes in their chronology the 'Middle' Pleistocene. But as we know the relative age within the European Pleistocene of the fauna accompanying Pekin Man, it is possible to assign to the entire *Pithecanthropus* group an absolute age as found for the Lower Pleistocene of Europe, i.e. about 500,000 years.

At the end of the First Interglacial, or even early in the Antepenultimate Glaciation, we encounter Heidelberg Man (*Homo heidelbergensis*) in western Europe. Only his jaw is known (Fig. 9). This is larger and more massive than that of modern man and possibly suggests a gigantic race. Professor Weidenreich thinks it is a forerunner of the Neanderthal group of Man which, however, is very much younger. The age of the Heidelberg jaw is geologically better established than that of many other human fossils; it falls near the end of the Lower Pleistocene, about 450,000 years ago.

The discovery by Mr. A. T. Marston of part of a human skull in the Thames gravels of the 100-foot terrace at Swanscombe in Kent confirmed to some extent an earlier find made in the neighbourhood long ago, called Galley Hill Man. The evidence for the latter being a genuine mid-Pleistocene specimen was not convincing and was refuted by the experts of the time. Between Galley Hill and the discovery of the Swanscombe specimen, however, human palæontology had turned away from the old hypothesis that the evolution of man proceeded from Pithecanthropus through Neanderthal Man to *Homo sapiens*. This was because the skull discovered at Steinheim in Württemberg in gravels of Last Interglacial or earlier age (and therefore older than the majority of typical Neanderthal skulls) was in several respects less Neanderthaloid and more *sapiens*-like than one would have expected (Fig. 4). Now, Swanscombe Man (Fig. 3) proved to be within the range of *Homo sapiens* in the characters preserved or deducible, and he antedates considerably the entire Neanderthal group, with the exception of the Heidelberg jaw. On the astronomical time-scale, Swanscombe man is at least 250,000 years old.

On the time-scale, Swanscombe man stands just halfway between *Pithecanthropus* and modern man. About a quarter of a million years ago man's evolution had proceeded sufficiently far for the stage reached to be regarded as essentially *sapiens*-like. The further evolution of this branch is picked up with certainty in Upper Palæolithic man of western Europe, during the first interstadial of the Last Glaciation—about 80–100,000 years ago. Europe, having for some time been the abode of Neanderthal man, was then invaded by *Homo sapiens* who brought with him the Aurignacian civilisation. But even in the early stages of this invasion we encounter several races of *Homo sapiens*, such as that of Combe Capelle in France (Fig. 6), the so-called 'negroids' of the Grimaldi caves on the Italo-French Riviera, and Cro-Magnon man. The Cro-Magnon group again can be divided into a western and an eastern type. I cannot here describe the racial divisions of early *Homo sapiens*. It is evident that when he first appeared in Europe, say about 90 thousand years ago, races were in existence already. Their evolution lies further back in the past. This inference strengthens the claims of Swanscombe man for '*Sapiens*-status'.

The evolution of *Homo sapiens* from the Swanscombe level to what he appears as in the Upper Palæolithic invasion must have taken place during the Penultimate Glaciation, the Last Interglacial and the first phase of the Last Glaciation. Most of this time Neanderthal man was present in Europe, and the evolution of *Homo sapiens* appears to have taken place elsewhere. From this point of view the recent discovery of a *sapiens*-skull in a river terrace at Keilor in southern Australia is of great interest. Provided that the description of the geological circumstances of this find can be confirmed, then *Homo sapiens* was present in Australia in the Last Interglacial. He must have got there almost certainly from Asia at a time as early as, or even earlier than, the Neanderthal period in Europe.

While the line of *Homo sapiens* was evolving outside Europe, another race of man, primitive in some characters and specialised in others, occupied the scene in Europe and western Asia and possibly elsewhere.

The earliest dated finds of this Neanderthal race are from the Last Interglacial, very approximately 150,000 years ago. The early Neanderthalers, however, approached *Homo sapiens* in some respects (Fig. 4), whilst the late ones from the first phase of the Last Glaciation (about 115,000 years ago) show 'Neanderthaloid' features in the extreme (Fig. 5). This suggests an evolutionary side-line which branched off from some more *sapiens*-like ancestor in the middle Pleistocene or is derived directly from a pithecanthropoid ancestor in the lower Pleistocene, and which became extinct in or after the first phase of the Last Glaciation.

The picture of the chronology of early man as afforded by the still scanty evidence is as follows. Some 10–15 million years ago, man's ancestors were apes of the *Dryopithecus* type. Perhaps a few million years ago a stage represented by *Australopithecus*, still an ape, had been reached. The passage from ape to man (as a genus) is likely to have occurred a million years ago or earlier. This is an estimate based on the degree of difference between *Pithecanthropus* and apes, though it of course depends on what one regards as the decisive human character: erect posture, the dentition, or the size of the brain case. The first of these characters was by far the earliest to appear.

Half a million years ago, *Pithecanthropus* lived in Java and China and probably elsewhere. A quarter of a million years ago, one branch had reached at least in some characters of the brain case the stage of *Homo sapiens*. But another branch of *Homo* developed into the Neanderthal race, which flourished about 150–100 thousand years ago and then became extinct, while *Homo sapiens* was extending his realm over the habitable earth.

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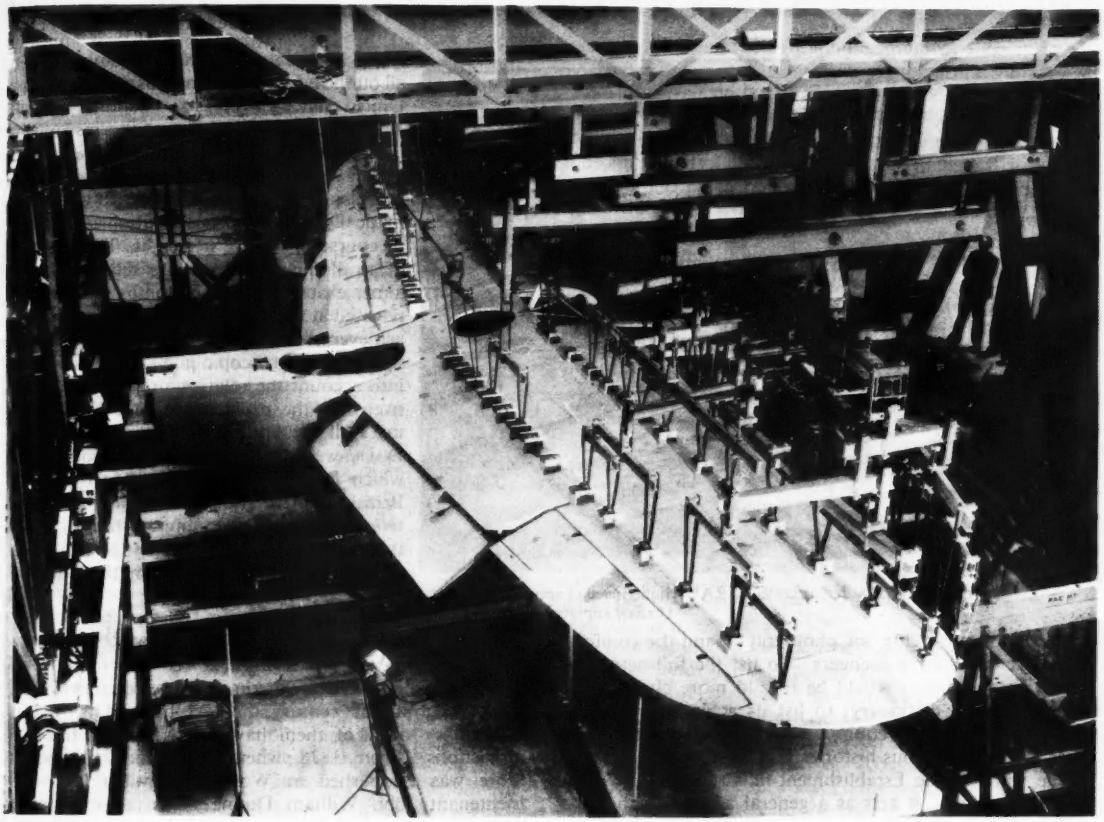


Wing of a Barracuda aircraft being tested to destruction at the Royal Aircraft Establishment. (*Crown copyright.*)

FAMOUS SCIENTIFIC INSTITUTIONS—IV

The Royal Aircraft Establishment

J. STUBBS WALKER

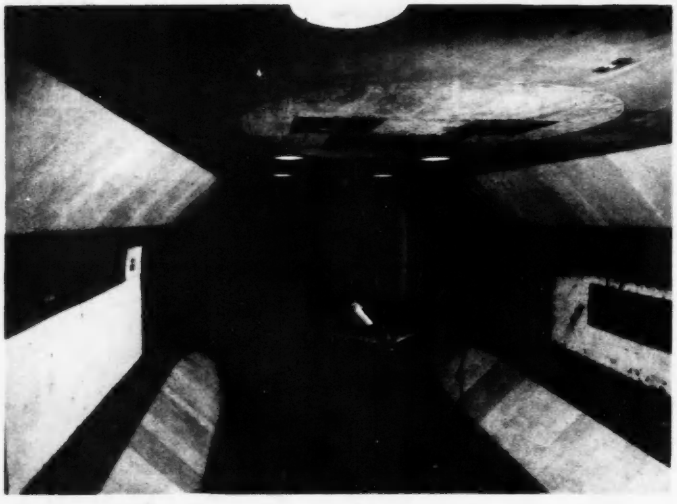
It is often said that nothing but evil comes of war. But however great was the evil of the last two World Wars, we can look back on the 1914–18 affair and be grateful that it helped to inspire the almost bean-stalk growth of the most vital institution behind British civil and Service aviation—the Royal Aircraft Establishment at Farnborough.

The RAE, known throughout the aviation industry and the Royal Air Force as 'The Factory', is, of course, much older than the first of the World Wars. Its roots were planted nearly seventy years ago when in 1878 a group of Army aeronautical enthusiasts persuaded the War Office to allocate the first Air Estimate of £150 for the building of a balloon at Woolwich Arsenal. (There was, by the way, a considerable saving on this, the first of all Air Estimates. The balloon, of 10,000 cubic feet capacity, and made of varnished cambric, was built for a total cost of £71.)

It was from these very modest beginnings, which were frowned upon by most of the War Office officials as 'wasteful and extravagant', that the present £20 million scheme for building an entire research town, with a personnel of 5,000 men and women workers, near Bedford, has grown. This new vast research station is planned to become operational in 1952 and will be known as the National Aeronautical Establishment. It will be the direct descendant of the present RAE at Farnborough and will centralise all the aeronautical research sponsored by the Government.

Until Bedford comes into being, however, Farnborough will carry on the Government aeronautical research work which, as speeds increase and the technical complications of the flying machine are multiplied, becomes of greater and greater importance.

The work of the RAE spreads from the basic science of aerodynamics, in which theoretical study, laboratory work and flight testing must be co-ordinated, to the individual



Model of DH108 Jet aircraft in RAE High Speed Tunnel. (*Crown copyright.*)

problems of gun-sights, air photography and the comfort of air crew and air passengers. To list the full activities of the Establishment would be to add more chapters to an aeronautical dictionary; to list its achievements even in brief details would require a volume roughly the weight of Mr. Green's famous histories.

The work of the Establishment falls roughly into two divisions. Firstly, it acts as a general adviser to the aircraft industry and the Royal Air Force on design problems of aircraft engines and aircraft. Its research teams are engaged on theoretical and experimental work on the ground and in the air. Aerodynamics, power plants, aircraft structures, materials used for aircraft and engines are the principal headings. At the moment one of the main preoccupations of the Establishment is in overcoming the trans-sonic barrier. This work is culminating this year in the launching of 'expendable projectiles' which will be released from Mosquitos flying over the Atlantic and which will telemeter to ground observers vitally important information on what happens to the craft when they reach trans-sonic speeds. All the information and knowledge which the RAE teams amass is given freely to the industry and there is a very free interchange of information, ideas and experience between the Farnborough scientists and the design groups of the individual aviation firms.

The second division of the Establishment's work is in the field of equipment for aircraft. Their technicians have a not unnatural pride in their achievements in the field of autopilots, navigation instruments, bomb- and gun-sights and the highly important radio and radar developments. Even the technique of dropping airborne forces, the towing of gliders and the problems of dropping guns and jeeps came within the enormously wide field of investigation of the Farnborough men and women.

One of their lesser known but actually most important achievements in this second division of their activities was the design of the famous Mark XIV bomb-sight. The Mark XIV was the standard bomb-sight in all our heavy bombers and was adopted by the United States air forces and manufactured in America. Great advantage of this instrument is that it allows the aircraft to take evasive action during the bombing run, it demands no calculation by the bomb aimer and automatically takes into consideration any change of course or change of height. The position of an illuminated cross-wire tells the bomb aimer exactly where his bombs will drop if released at that instant. A somewhat similar achievement by Farnborough during the last war was a gyroscopic gun-sight which took into account the relative aircraft speeds and overcame the problems of deflection shooting. All the Spitfire squadrons engaged on D-day were fitted with the gyroscopic sight which had been proved in American and British gunnery trials to increase the effectiveness of aircraft-to-aircraft fire by from three to five times—equivalent to increasing the aircraft's armament from three to five times!

How the RAE grew

From the first balloon experiments three-quarters of the way through the last century, the RAE has had its troubles in plenty. Many of them have been through financial restrictions. From 1878, when the Balloon Equipment Store was established at Woolwich until 1905, when Lieutenant John William Dunne began to experiment with a glider, the accent of official activity was on balloons. The scene of activities was shifted from Woolwich to Chatham in 1882 and in 1886 a balloon school was established at Lidsing, near Chatham. This, though, was made possible only by the action of Major J. L. Brooke Templer, who was director of the Balloon Equipment Store. He used his private means to help finance the school. The following year, however, he was appointed officially as 'Instructor in Ballooning' by the War Office at a salary of £600 a year.

Later in the century, after the Balloon Equipment Store had become the Balloon Factory and Balloon School, activities were moved from Chatham to Aldershot. In 1890 an Air Estimate of £4,300 was voted. Soon after activities had started at Aldershot, the first official heavier-than-air experiments were made. In 1894, a man-lifting kite section was added after successful experiments at Pirbright and Farnborough by Captain B. F. S. Baden-Powell of the Scots Guards.

A red-letter day for the budding RAE came in 1899. After their years of experimental work and training, the aeronauts at Aldershot were ordered by the War Office to step up their production of balloons and send detachments to South Africa for the Boer War. It must have been a satisfying moment for Lieut.-Col. Brooke Templer. He had started the first official balloon experiments 21 years before, when he was a captain in the 2nd Middlesex Militia. He had risen in rank to lieutenant-colonel and was still the man in charge of the War Office activities in the air, with the official title of Superintendent of the Balloon

Factory. He deserved his moments of elation when his balloons were ordered to war; in the next few years he was to face bitter disappointments. In 1902, the Air Estimates were halved—from £12,000 to £6,000—just as he was beginning experiments on non-rigid airships. In 1904 after some failures, lack of funds stopped the experiments.

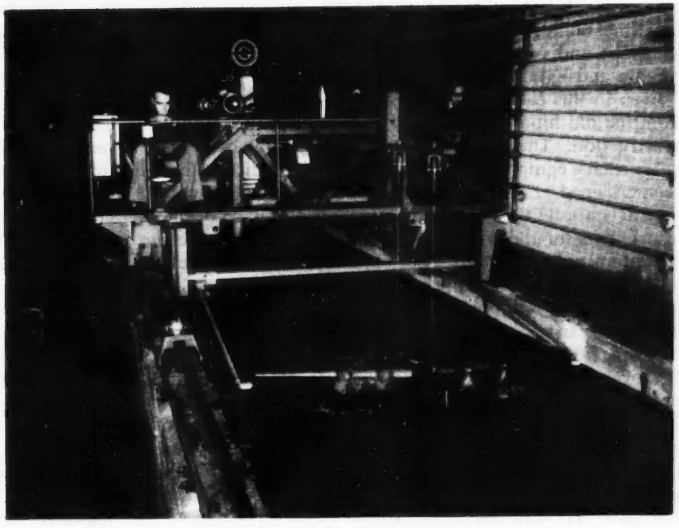
In 1904, too, the Treasury made a decision which possibly had an extremely important bearing on the development of heavier-than-air flying in Britain. Colonel J. E. Capper was sent to North Carolina by the War Office to persuade the Wright Brothers to come to England and continue their heavier-than-air experiments. When all arrangements had been completed, the Treasury stepped in and refused to sanction the necessary expenditure.

Most important date in the development of the aeroplane was 1907 when J. W. Dunne's first aeroplane was given its first tests. These were carried out at Glen Tilt, Blair Atholl, in absolute secrecy. The party of men who travelled north for the flights were ordered to wear civilian clothes for the journey. Their trip, however, was hardly a triumph. After making a successful soaring glide, the machine was wrecked.

The first free flight by a power-driven aeroplane at Farnborough was made in 1907, when S. F. Cody flew a modified man-carrying kite fitted with a 12 h.p. Buchet three-cylinder engine. It is of interest to point out that a withered fir-tree is still preserved at Farnborough. It bears the inaccurate inscription: "This tree was used as a picket for the aeroplane belonging to Colonel Cody, a pioneer of aviation during the year 1911." S. F. Cody's aeroplane was certainly tied to the tree, but (*a*) S. F. Cody was not a colonel, and (*b*) he left Farnborough in 1909. The fir-tree, which is at the beginning of the present long runway at Farnborough, has, despite its inaccurate inscription, become a point of interest for visiting Americans!

The years before the first World War were crowded with aviation interest. Farnborough took its part. The airship, *Nulli Secondus* flew from Farnborough to London at an average speed of 16 miles an hour and landed at the Crystal Palace. It was in the air for three and a half hours and set up an endurance record for non-rigid airships. Experiments which were attracting considerable attention were being made with wireless equipment carried by balloons, and as early as 1908 successful ground-to-air communication was made over a distance of twenty miles.

Work was going ahead on aircraft built by Dunne and Cody, and they were meeting with some success until, in 1909, the War Office decided to cease making experiments with aeroplanes *as the cost had proved too great*. The cost, in actual fact, had by then gone up to a total of £2,500 spent on the experiments! The powers-that-be, however, relented two years later. A young man named Geoffrey de Havilland sold to the War Office for £400 an aircraft he had designed. It was powered with a 45 h.p. engine, also the design of de Havilland, and was renamed the F.E. 1—the first of the series of Farnborough aircraft.



Model flying boat running in Seaplane Testing Tank.
(*Crown copyright.*)

De Havilland became designer and test pilot of the Balloon Factory.

A delightful example of how, even in those days, it was necessary for the enthusiast to 'get round' officialdom, happened at Farnborough in 1910. A Bleriot monoplane, known as the 'Man-killer' on account of its bad flying habits, was sent to the Factory for repair. In asking for authority to do the work, the staff at Farnborough asked the Master-General of Ordnance that the authorisation should cover 'reconstruction'. When the Bleriot had been 'repaired' it re-appeared as a *biplane* of the canard or tail-first type—moreover the original Bleriot was a tractor monoplane, and the only part of the 'repaired' machine that remained was the engine! Work on this plane was directed by Mervyn O'Gorman, who had been appointed superintendent of the factory in the previous year. Design work was carried out on it by de Havilland and Mr. F. M. Green who had joined the Factory from the Daimler Company.

The air became of greater importance than it had ever been in those few years immediately before the war. In 1911, the first Air Battalion was formed, "to which will be entrusted the duty of creating a body of expert airmen, organised in such a way as to facilitate the formation of units ready to take the field with troops". In addition, the Air Battalion was entrusted with the training of men "in handling kites, balloons and aeroplanes and other forms of aircraft". The 1911 Air Estimates, too, indicated that the War office was realising the importance of flying. A sum of £85,000 was granted for new dirigibles and aeroplanes and a further £28,000 was allocated for the construction of a new large shed at Farnborough. Things were looking up, and the Balloon Factory received the rather grander title of the Army Aircraft Factory. The following year, it became the Royal Aircraft Factory and a White Paper, 'Memorandum on Naval and Military Aviation,' laid down its functions. They were: "The higher training of mechanics for the Royal Flying Corps;

tests with British and foreign engines and aeroplanes; experimental work; the existing work in manufacture of hydrogen and generally meeting the requirements of the Airship and Kite Squadrons."

Even in this early period the Factory was getting away from the old hit-and-miss methods of aircraft design and construction. The experts, too, were beginning to work on ancillary equipment. The first air-speed indicator had been designed. For the 1912 Military Aeroplane Competition at Lark Hill, the Factory had produced recording instruments for the aircraft, including recording air-speed indicators and aneroids, petrol and oil-flow meters, revolution indicators and pressure gauges. From then on, this side of the Factory's activities began to grow in scope and importance.

From 1912 until the end of the first World War, the Factory's achievements are already famous. In 1913, the first of the almost legendary B.E. 2 aircraft was built to the design of Mr. E. T. Busk. This aircraft was one of the best known of the war, and more than 2,000 were built. Busk, unfortunately, lost his life in one of these aircraft in 1914 when it caught fire in the air at Farnborough. He was then only 28.

Expansion in World War I

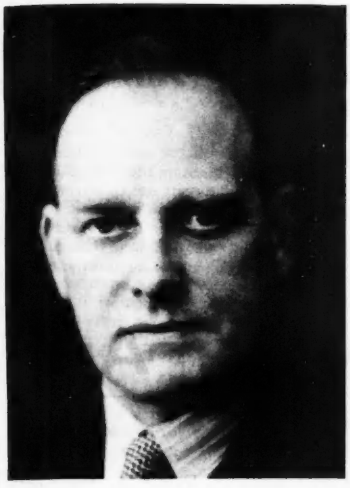
The war-time importance of aviation meant a tremendous growth in the activities of Farnborough. By the middle of 1915, the handful of enthusiasts had grown to a staff of 4,000. By the end of the year the staff had increased to 5,000, including 3,000 women. The Factory really was a factory, almost more than it was an experimental centre. The famous RAF aero engine was being built, and aircraft were being constructed on the production line system. There was criticism of the organisation, despite the success of its products, and a committee appointed by the War Office decided that it should concentrate on the research and development aspects of aeronautics rather than engage in production. That was in 1916, and from that time until the end of the war, the Factory was responsible for such designs as the S.E. 5 biplane scout, of which more than 5,000 were built by outside firms; the B.E. 12, used in attacking Zeppelins; the R.E. 8 two-seater reconnaissance biplane of which 4,000 went into service; and the F.E. 12, a two-seater night fighter which was equipped with searchlights and a rocket gun!

In June of 1918, the Factory received its present title, the Royal Aircraft Establishment, and, with the end of the war, the fierce tempo of its activities began to slow down. Development work went on, though, in all aspects of aviation. The civil aspect of flying came into the limelight again. War-time development had shown that what was a dream in 1914 could be made a reality. Farnborough—still known as 'The Factory' wherever aeronautics were discussed—was now better equipped than even the most hopeful of the earlier enthusiasts could have hoped. As far back as 1913, the basic principles had been laid down for the stressing of aeroplane structures. Wings, held rigidly on trestles, had been tested with sandbags of known weight, and the first of the 'tests to destruction' had been originated. There was closest possible co-operation between the National Physical Laboratory at Teddington and Farnborough with its own whirling arm test house and wind-tunnels from which data on aerofoils could be obtained.

Some idea of how far aeronautical science had been developed during the first war can be appreciated by the fact that they had accomplished test and development work on variable pitch propellers, had designed light-weight wireless sets for aircraft, had carried out wind-tunnel tests on models and confirmed the tests in flight by full-sized aircraft. Their stress experts had enabled a very great saving to be made in aircraft structure weights by the precision of their strength calculations, and they had already begun to obtain accurate knowledge of the metals used in aircraft production. Aircraft instruments were much more accurate, thanks to their technicians, and such things as aircraft fabric dope with the valuable quality of excluding the actinic rays from the fabric and thus preventing its deterioration had been produced. The problem of spinning had been tackled and solved. Radio-controlled aircraft had been experimented with, and the scientists were working on a problem which is still not completely solved—helicopters. Two- and three-engined aircraft had been designed. On the engine side, they had made progress with such 'modern' ideas as the sleeve valve for aero engines, supercharging and the measured injection carburettor. In all, a gallant achievement.

There was a lull after the war. The staff of the Factory dropped and dropped. During the crisis years, its finances were severely restricted. But the work went on. The rush of the war-time development, which had shown the real worth of the RAE had stopped, and the scientists not only of Farnborough but of the aircraft industry generally began to tidy up the aeroplane and all its associated equipment. High altitude flying became of importance. The safety of flying becomes a number one priority consideration in peace, though risks can be taken in war-time. The Farnborough scientists tackled those problems, among others. Speeds of aircraft began to go up to the three hundred miles an hour mark, and the wind tunnels of Farnborough provided the background of research which resulted in the famous Gloster and Supermarine aircraft which upheld Britain's prestige in Schneider Trophy Contests. The idea of airships was reborn and for years before the R. 100 and R. 101 were built, the Factory worked on the problems associated with their construction. The radio side of aviation came in for very detailed attention, while steadily, independent research continued and, despite the financial crises of the country, the Farnborough equipment improved and expanded. When an expansion of the impoverished RAF was called for in 1935, the Factory was ready to take its position as adviser and consultant to the aircraft industry and to the Services. The aircraft firms who had been starved of orders during the lean years, could never have afforded to keep themselves abreast of all the developments of the air during that period, and Farnborough was able to give the advice that resulted in some of our finest aircraft.

Throughout their work, the Farnborough scientists have worked steadily not only on basic investigation but have made a continuous study of aircraft troubles. Every type of accident is reported on, failures of aircraft parts are investigated and methods of preventing their repetition are formulated. The RAF co-operate by giving the



Mr. W. G. A. Perring, present Director of RAE

Mr. W. S. Farren, Director from 1941 to 1945.

Mr. A. H. Hall, Chief superintendent of RAE, 1928–1941.

scientists the benefit of all their flying experience. The Establishment, in fact, can fairly claim to have made substantial contributions to the evolution of most modern types of Service and civil aircraft. Work by RAE metallurgists played a big part in the production of the gas turbine and they made their contribution, too, to the essential development of the high-speed, high-efficiency impellors and turbines for the jet engines with which this country has led the world.

Present work is not likely to be disrupted so much as it was after the last war. The Ministry of Supply and the Air Ministry (and, fortunately, the Treasury) appreciate that the work of the RAE must not only go on, but must be enlarged in scope.

Aeronautics is now at a point of development which can be likened to the change-over of interests from the balloon to the heavier-than-air machine. That is why Farnborough —and, eventually, the research 'town' at Bedford—are of an importance that both the Government departments and the public must always bear in mind. It is difficult to tell the member of the public that the millions of pounds that must come from his pocket to pay for the development of, say, the laminar flow wing, is well spent. Farnborough surely has given its own proof that, even if it is expensive, it shows a handsome profit to the nation in the work it has done. The work it is doing now is of even greater importance.

The Sonic Barrier

The aircraft is about to break through the sonic barrier of speed. No one—not even the experts at the Factory—can foresee exactly what will happen when that has been done. In order to achieve the speeds that have already been reached, thousands of man-hours have been put in by the scientists. The high-speed wind tunnel at Farnborough is capable of testing models up to a six feet wingspan at speeds of 600 miles an hour. But what happens after that? Every wind tunnel test has been followed by flight test. A Spitfire, for instance, was dived by a Farnborough test pilot from 40,000 feet to reach a speed equal to 90 per cent of sound. This kind of work must continue if there are to be any further steps forward in flying.

Farnborough, too, realises the vital importance of security in aircraft. Apart from the scientific and engineering departments that have worked on the prevention of fire in aircraft, the strength of structures used in building planes, the whole question of the comfort and safety of air crew and passengers is looked after at the Factory by the RAF Institute of Aviation Medicine. The RAF doctors on the RAE staff themselves have to undergo many of the tests, some of which entail considerable discomfort. Members of the staff, during the war, went out on bomber operations in order to gain first-hand experience of the medical side of flying. The war-time investigations were largely of an *ad hoc* nature, but now long-term research is being undertaken. Conditions of flight in aircraft with modern performance have already reached the limit that the human body can stand in an emergency and the solution to this particular problem is being searched for by an integration of effort by engineers, physicists, aerodynamical experts and physiologists.

The future? Who would dare to make a forecast when it has been proved in our lifetime that actual progress can outstrip the imaginings of the sensationalist? Who dare say that the true solution of supersonic flight does not already lie in the pencilled figures and tentative lines on some designer's drawing board? The gas turbine, despite its achievements, has not yet reached its early adolescence of development. Only technical problems that are well within our compass to solve prevent true stratospheric flying.

The brains of the Factory are already treating with these things. May they bring to the problems the same enthusiasm, ingenuity and eventual success that have marked their seventy years of achievement.

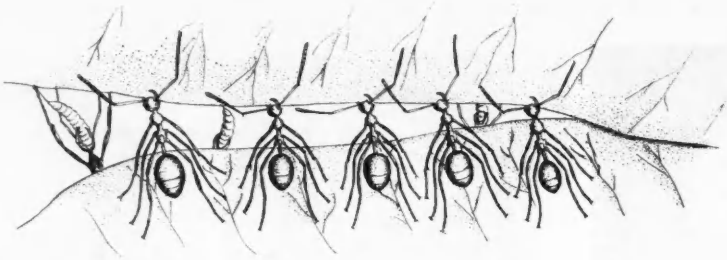


FIG. 1. A brigade of spinning ants, *Oecophylla smaragdina*, draw the edges of leaves together while other workers bind them together with the silk spun by the larvae.

One Ant Nods to Another Ant

DEREK WRAGGE MORLEY, M.A., F.L.S.

One ant nods to another ant,
And then they run and run,
From East to West and West to East,
As on some urgent business bent.
Tachibana Akemi (1811–68)

SINCE the earliest times of which we have any record, men have watched the ants and marvelled at their industry and social organisation. Much of this early observation and comment is of little value because of its inaccuracy and the unscientific outlook of the observers. A lot of the early literature about ants is pure myth, based simply on this reputation for industry and social organisation. Thus Aelian in *De Natura Animalum* states that in the first day of the month no ant ventures from the nest, and he even uses this astonishing piece of information as an argument to show the poverty of learning of the Chaldeans and Babylonians in matters of astronomy. Herodotus quoting Demetrius Triclinus repeats the Eastern Legend of a species of ant "not so large as a dog, but bigger than a fox" which was supposed to live in the desert and mine gold.

Yet knowing as we do now so much more about the mechanisms of the behaviour of the ants, of their division of labour (which so interested and puzzled Solomon, most accurate of all ancient observers) and social organisation, they still present some of the most fascinating of all scientific problems and studies.

It has long been known that ants 'herd' aphides, guarding them from predators and parasites, often carrying them from the nest each morning to the leaves for 'pasture' and bringing them back again each night. Some ants even build earthen sheds over the aphides to protect them.

The behaviour of the harvesting ants of Eastern and Southern Europe, Africa and the Middle East in gathering in seeds and grain at harvest time is recognised in the old Jewish Mosaic Law, which states that the seed found in their nests must be given to the poor. These ants, most of which belong to the genera *Messor* and *Pheidole*, keep the seeds in special chambers where they start to germinate. The ants then cut off the radicle of the seeds and bring them out into the sun to dry, and the starch which the seeds contain is turned to sugar.

A somewhat similar habit is found in the South American fungus-growing ants (the *Attini*) which gather leaves off trees and, after chewing them, place the pulp in subterranean chambers, where it is used as a manurial bed on which to grow the fungi on which the ants live. The species of fungus found in these fungus-gardens often varies from ant genus to ant genus. The spores of the fungus are carried by the queens in the infra-buccal pouch on the nuptial flight. Almost the first action of a queen on finding a suitable place for the foundation of a new colony is to start a small fungus bed which she infects with these spores and which she manures with her excreta until the first workers hatch out.

Less well known is the nest-building behaviour of the spinning ants of South Africa and Australia (*Oecophylla*) which use their larvae, which have well-developed silk glands, as living shuttles to sew together the leaves which form the exterior of the nest. The ants form living chains from the tip of one leaf to another, gradually pulling them together, when other workers sew them into position with the silken thread produced by the larvae (see Fig. 1).

Solomon's statement that the ants "have no guide, overseer, or ruler" (Proverbs vi. 6, 7, 8) has spurred many students of animal behaviour to try and find out more about the activity of the individual ant and its integration into the social pattern. In the last few years our knowledge of this aspect of myrmecology has made great strides.

Their Ability to Learn

T. C. Schneirla of the American Museum of Natural History has performed numerous experiments both in the field and the laboratory to try and find out how far the power to learn exists in ants, and what part it plays in the behaviour pattern. He found that the ability to learn varied greatly even between individuals of the same colony, and that some ants quickly mastered simple mazes (Fig. 2). On the other hand he could find no evidence of reasoning ('insight learning').

S. C. Chen has shown that there are hard-working ants and lazy ants and that they have a stimulating or narcotic effect on their nest-mates.

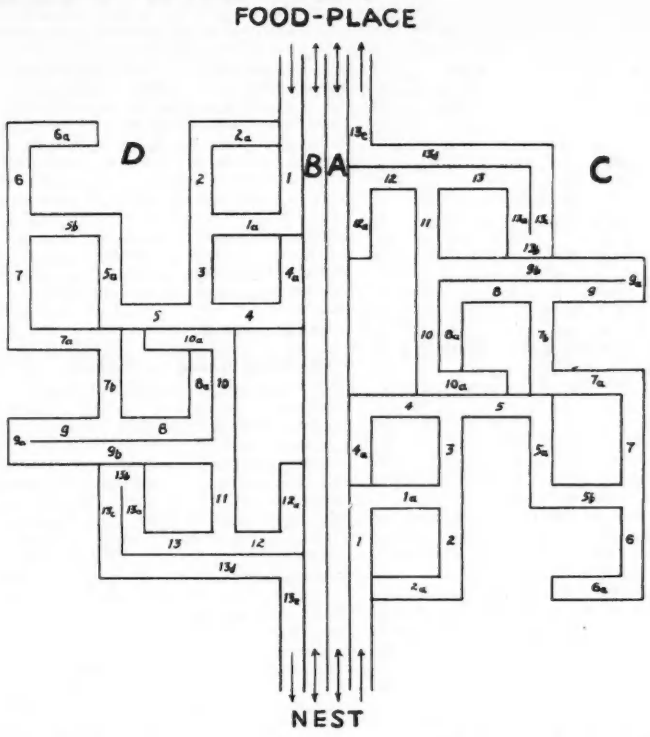


FIG. 2. The ant maze used by T. C. Schneirla to test the ability of ants to learn. The maze is situated between the nest and the food place. The ant is first allowed to follow the direct route *A* to the food, and a similar direct route home, *B*. Next the ant is made to learn its way through the maze *C* to the food, the speed with which it learns to avoid the culs-de-sac being observed. It is allowed to return by the direct route *B*. Later the situation may be altered so that it approaches the food by the direct route *A*, and returns through the maze *D*; or goes out through maze *C* and returns by maze *D*. Individual ants vary greatly in their ability to learn the way through these mazes.

T. Suncliffe Barnes has found that active individual workers may stimulate other workers into sheer physical activity even where there are no tasks available.

Behind this recent work there is a vast literature of past research, discussion and synthesis running into hundreds of volumes filled with great names.*

We know that some kinds of ants appeared on the earth long before others and some of these ants are still found today. The development from these small primitive communities of the early ants to the enormous complex communities of the later ants can and has been studied. In the later communities all the ants seem to work for the common good and the work is shared—the so-called 'division of labour'. In the earliest ant communities, each ant seems to work more for itself and does not bother much about the others. Yet the later ants differ much more from one another in their behaviour than the earlier more primitive ones; they may learn to do different jobs, or to do the same job differently. No two ants learn to do the same job in quite the same way—they learn to build differently and to search for food in different places. One ant may learn to look after the greenflies which the ants milk, and another to hunt for insects to eat. An ant may do both, but will tend to do one more often.

* *Réaumur* (who invented the thermometer), *Huber* (the "father of myrmecology"), *Wasman* (who made an especial study of the 'guests' found in ants nests), *Janet* (who worked out the ant anatomy in great detail), *Forel* (also an eminent psychologist), *Emery* (a great taxonomist), *Wm. Morton Wheeler* (probably the greatest of all students of ants), and *Donisthorpe* (the living patriarch of myrmecology).

In the more primitive ants the individuals behave very much like one another. They do things separately yet are more like living machines than those living in the larger later-developed communities which differ so greatly in their ability to learn and the jobs they do.

That this 'individuality' should reach its highest development in the ants belonging to the sub-family *Formicinae* where the social integration is greatest has seemed to some workers to be surprising. It appears, however, that the mechanism is a simple one, depending on the reaction of the individual ants to external and internal (physiological) stimuli and the very quick reaction of individual ants to the activities of their neighbours.

The wonderful 'organisation' of the ant colony now appears to be a purely casual mechanism in which the individual variation in ability to learn, and in reaction to stimuli plays a great part. While the presence of the queens as living mothers in the midst of the sterile workers is an important factor in the integration of the colony.

There does not appear to be (despite the belief of earlier workers) any well-developed method of communication in ants, but only the most primitive attention-attracting stimulation or gesticulatory feeler-tapping. This proves perfectly adequate for the working of the mechanism of division of labour.

Much work is being undertaken in all the many branches of this fascinating study, only a few of which have been mentioned here, yet more remains to be done than has been undertaken: more problems await solution than have been solved.

Far and Near

Official Research and Development

CONCERN at the serious delays, which are holding up the implementation of the Government's plans for atomic energy development, is expressed in the report of the Select Committee on Estimates which deals with expenditure on research and development in official establishments. The report mentions serious delays still occurring in the construction of the Atomic Energy Research Establishment at Harwell, and though this work has been given highest priority the Committee feel that this categorisation is meaningless unless methods are provided to obtain all necessary supplies and recommend an immediate independent inquiry into the organisation of the atomic energy project.

In an appendix to the report the Ministry of Supply give a sketchy schedule for construction activities at Harwell. The first pile, a low power graphite pile of relatively simple construction, has come into operation (see 'Progress of Science') thereby making the relevant section of the appendix out of date. This document states that the second pile, which will provide information required for the application of atomic energy to the development of heat and power and also supply radio-active isotopes in quantity, will not be working before the summer of 1948.

This official document collects together useful facts on many aspects of Government science and some statistical information. It gives a figure of over £69 million for the total estimated expenditure for 1947–48 on Governmental research and development. The largest sums of money go to the Admiralty and Ministry of Supply (£60,351,000) and Department of Scientific and Industrial Research (£3,118,289). Industrial research by other departments accounts for £1,501,500. The other items are: Post Office Research, £750,000; Agricultural and Fisheries Research, £2,150,925; Medical Research, £710,850; Research in Dominions and Colonies, £538,825. Finally £70,560 covers grants to various scientific bodies such as the Royal Society.

The report points out that grants to universities and similar institutions must also be taken into account when attempting to estimate the total expenditure on research and development, and the committee suggests that this total is about £76,500,000

Nearly two-thirds of the total sum is spent on defence research, and the report poses the question whether this represents an equitable distribution between civil and military needs. Attention is also drawn to the insignificant figure allocated to Colonial research—a mere 0·7 % of the total.

Scientists Condemn Biological Warfare

A RESOLUTION condemning all forms of biological warfare and calling on microbiologists throughout the world to do everything in their power to prevent it was adopted by the Fourth International Congress of Microbiology meeting at Copenhagen in July. The Congress resolution read as follows: "The Fourth International Congress of Microbiology joins the International Society of Cell Biology in condemning in the strongest possible terms all forms of biological warfare. The Congress considers such barbaric methods as absolutely unworthy of any civilised community and trusts that all microbiologists throughout the world will do everything within their power to prevent their exploitation." A similar resolution had already been passed by the International Society of Cell Biology, meeting in Stockholm.

Photography in Industry Exhibition

THE Exhibition of Applied Photography which was organised in London by Kodak recently, and which was the subject of an article in the June issue of DISCOVERY, is touring the provinces. After a five-day stay at Leeds at the beginning of September it goes to 244 Deansgate, Manchester (September 29–October 3), McLellan Galleries, Sauchiehall Street, Glasgow (October 13–17), Chamber of Commerce, Birmingham (October 27–31) and winds up at the City Museum, Queen's Road, Bristol (November 10–14); times 10 a.m. to 5.30 p.m.

The Exhibition provides a practical demonstration of the usefulness of photography in document copying, stress analysis, X-ray inspection of castings and welds, data recording, motion study, air survey, visual aids to teaching, etc.

Admittance is by invitation, and those interested are invited to apply to Industrial Sales Dept. Kodak Ltd., Wealdstone, Harrow, Middx. There will, however, be one day at each centre open to the public.

Science and the Crisis

WHAT science could do to help to increase production and so reduce the dangerous gap between British exports and imports forms the subject of a statement issued by the Executive Committee of Scientific Workers on August 12. Six main proposals for immediate steps which would bring science to bear on the economic crisis are made. These are:

1. The Advisory Planning Board to the Cabinet should be enlarged by the addition of three scientific and three technical members.
2. The Advisory Council on Scientific Policy should be urged to proceed with a plan for the immediate and effective utilisation of science and technology in industry and agriculture, and be given powers to see that the plan be implemented.
3. At least a third of the scientific manpower, laboratories and equipment of the defence services should be diverted to civil production work, where possible taking the problems to the laboratories and staffs.
4. Steps should be taken, similar, but more extensive, to those taken in the war, to pool scientific research and development work in the essential industries and to provide opportunities for scientific workers and equipment in unessential industry to be used for more important work.
5. The formation of regional research councils linked with the central organisation of production and research should be encouraged.
6. Scientific and technical workers should be specifically represented both on existing Production Committees and on all subsequently set up.

Deep Sea Research

Two scientific expeditions to study deep-sea conditions have been announced. The first is a Swedish expedition, led by Professor Hans Pettersson, director of the oceanographical institute at Gothenburg, which has already set out on a cruise that will last approximately fifteen months. The research vessel being used is a 1400-ton motor schooner. This expedition will be taking samples of the ocean bed with a piston core sampler designed by Dr. B. Kullenberg, which has been thoroughly tested in the Mediterranean where it proved effective for obtaining samples twenty to fifty feet long at depths of 1000–2000 fathoms.

The Belgian scientists Professor Piccard and Dr. Max Cosyns will be attempting this month or next to descend 2½ miles—the descent will be made in the Gulf of Guinea, N.W. Africa—into the sea in a submarine balloon or bathyscape. According to a report in *The Times* the spherical cabin of the bathyscape has a diameter of 5 ft. 6 in. and to resist the heavy water pressure it has been made of a special alloy which is 3½ in. thick except around the portholes of transparent plastic, where the thickness is 6 in.

Radio-Isotope Research in U.S.A.

THE U.S. Atomic Energy Commission released last month an anniversary report summarising the first year's work of U.S. scientists with radio-isotopes. The report records studies and experiments carried on throughout America with radio-isotopes, whose most important single contribution to mankind, the Commission says, is as a research tool evaluated as at least equal to the microscope in opening new fields of scientific endeavour.

The Clinton Laboratories at Oak Ridge are operated for the U.S. Government by the Monsanto Chemical Company. The first shipment of radio-isotopes produced at Clinton Laboratories a year ago was made to the Barnard Free Skin and Cancer Hospital in St. Louis, Missouri, for fundamental research in growth of tissues. In the last year Clinton Laboratories have made 1,092 shipments of radio-active elements to scientific and industrial research institutions throughout the continental United States and the territory of Hawaii. Production of more than 100 radio-isotopes is now proceeding.

These are some of the uses to which they have been put:

The initial shipment to St. Louis was a unit of radio-active carbon 14, and the research team working with it succeeded in tagging a cancer-producing agent, methylcholanthrene. With this tagged agent they are gaining a new approach to the problem of cancer development. They emphasised, however, that to make the most efficient use of this new and powerful tool of research has required development of unique laboratory techniques and equipment.

An interesting use of radio-active tracers is found in the work being done at Tulane University School of Medicine, New Orleans, Louisiana. There a scientist has been using radio-active sodium to determine causes and cure of edema in congestive heart failure.

In a Los Angeles hospital, a doctor has been using radio-phosphorus to compare circulation of normal hearts afflicted with coronary occlusion. As a result, it has been demonstrated conclusively for the first time that the heart contains accessory channels which could take over when occlusion or clogging exists. The same doctor also has been doing considerable research with radio-active iodine in hyperthyroid patients whose afflictions are too serious to make surgical treatment advisable.

A large monthly supply of radio-active phosphorus has been used at Washington University's School of Medicine in St. Louis, for treatment of patients with various types of chronic leukemia.

At the same school of medicine, radio-active iron is being used in the study of anaemia.

New York City's Memorial Hospital has undertaken an intensive research programme employing radio-isotopes in the study and treatment of cancer; cancer of the thyroid has been vigorously attacked in this study.

The National Institute of Health of the U.S. Public Health Service has found that radio-sulphur can be biologically incorporated into crystalline penicillin when penicillin is grown on media containing this substance. This will enable scientists to determine much more about penicillin and why it is able to combat diseases. By using radio-active penicillin the drug can be traced through the body.

The institute is also using radio-isotopes to tag bacteria. Tuberculosis studies are already under way and it is believed that many forms of bacteria can be tagged with radio-phosphorus and their means of entrance to the body and resulting action determined by tracer technique.

Radio-isotopes also are being used in industry—for experiments on friction, for instance, which may lead to important advances in treatment and composition of surfaces to reduce frictional wear in all types of machinery. Metallurgists also are finding many uses for radio-active tracers; they are studying such diversified problems as aging of ferrous materials by following the diffusion of carbon atoms, the thermionic activity of filaments, and the absorption of gases in metals.

In agriculture, use of radio-isotopes in research is expected to provide future dividends for the farmer. Radio-phosphorus is being used to study action of phosphate compounds in the soil, holding promise of improved fertilisers. Another study is the investigation of the effects of small amounts of minerals, especially copper and cobalt, on growth of pastures and on cattle grazing on those pastures.

The report points out how the use of the atomic pile for making radio-isotopes has reduced the price of these products. Before the chain-reacting pile was available, most radio-isotopes were made in cyclotrons in limited quantities. The estimated cost of cyclotron-produced carbon 14 was one million dollars per millicurie compared with the present price of 50 dollars for the same amount manufactured by means of the pile.

Director of Natural History Museum

MR. NORMAN BOYD KINNEAR has been appointed director of the Natural History Museum, South Kensington. Mr. Kinnear was educated at Edinburgh Academy and Glenalmond. From 1907 to 1919 he was curator of the Bombay Natural History Society's Museum. In 1920 he received a special appointment to the British Museum (Natural History), became deputy keeper in charge of birds in 1927, and Keeper of Zoology in 1945. He has been president of the British Ornithologists' Union since 1943. His predecessor, Sir Clive Forster-Cooper, who held the post since 1938, and who from 1914 to 1937 was director of the University Museum of Zoology, Cambridge, died in August at the age of 67.

UNESCO's Field Science Operations

MR. WILLIAM E. PURNELL, an Australian chemical engineer, has been appointed counsellor in charge of Field Scientific Operations for the Natural Science Section of UNESCO. His first task is the co-ordinating of the Field Science Co-operation Offices which UNESCO is setting up this year in Rio de Janeiro, Cairo and in China. A fourth office is being planned for South Asia to be opened next year in India. Eventually it is hoped to have several more of these scientific co-operation offices working in the various natural regions of the world.

Dried Egg and Food Poisoning

THE wartime introduction of dried eggs on a large scale—nearly a quarter of a million tons were imported in the period 1942–5—was followed by a great increase in the number of cases of food poisoning due to bacteria of the Salmonella group. In 1944, for instance, there were 454 such outbreaks, a figure greater than the total for the seventeen pre-war years. According to the latest Special Report of the Medical Research Council (No. 260, *The Bacteriology of Spray-dried Egg with particular reference to food poisoning*) the dried eggs, in many samples of which the bacteria have been found, were the likeliest cause of the food poisoning.

An appendix shows that the Ministry of Food was well aware of the risk before it adopted the policy of importing large quantities of dried egg, and that it embarked on that policy after deciding that the risk was outweighed by the necessity of maintaining food supplies at the highest possible level—from the nutritional point of view, dried eggs could stake a high claim for inclusion in the diet, being one of the most concentrated foodstuffs available, with a protein content of 47%. The Ministry consulted its Scientific Advisers' Division and the Medical Research Council, and then took steps to implement their advice that the danger of food poisoning would be greatest if the reconstituted egg were allowed to stand for hours before cooking. Catering establishments and canteens were warned to cook the egg soon after reconstitution. In the Ministry's experimental kitchens it was found that if that precaution was observed, relatively mild cooking, e.g. scrambling, was sufficient to kill any salmonella organisms that might be present. It was in the light of these experiments that the Ministry rejected recipes, for egg shakes, etc., in which the egg went uncooked. Orders were issued prohibiting the use of dried egg in ice cream and synthetic cream unless the mixture was pasteurised.

Radio Research in Britain

THE volume of British research in the radiofield is seriously inadequate to meet the demands for basic knowledge, and stands in an unfavourable relation to the efforts being applied in other countries, notably the United States. This is one of the main conclusions reached in a report entitled "British Research in the Radio Field", which the Institution of Electrical Engineers has just published. The report was drawn up by the Institution's Panel on Research in the Radio Field, composed of the following members: Sir A. P. M. Fleming, Drs. W. G. Radley and R. L. Smith-Rose, Messrs. T. E. Goldup, H. L. Kirke and C. E. Strong. The committee was reinforced by the co-option of Professor Willis Jackson and Mr. J. A. Ratcliffe.

Measures are suggested which would bring about an expansion of the radio research effort. First of these is the provision of greater financial support, preferably by Government grants, to academic laboratories. New buildings for research purposes should be erected concurrently with the national drive for rehousing, while steps should be taken to discover research leaders—the panel consider that all other factors are subservient to the availability of inspired research leaders.

The report stresses the need for a permanent cadre of research workers in university laboratories, so that a succession of post-graduate students can be effectively welded without unproductive loss of time into research teams engaged on continuing investigations. The members of this cadre should be paid salaries at least of the order of £500–£800 a year. Graduates who intend to do research work, the panel hold, would benefit if they spent immediately after graduation a period of not less than six months in industry, such industrial experience having a broadening and maturing effect on many men with a bent towards a research career. The return to a university should also be facilitated for those who

have spent one or two years in industry; more funds will be needed to support these men than is required for those staying in industry a shorter time, and here the report suggests that the Institution of Electrical Engineers should immediately award scholarships similar to the Ferranti and Oliver Lodge awards. The panel also consider how greater interchange of personnel could be arranged between industry and the universities; there should be increased opportunities for senior scientific workers in industry to return for a sabbatical year to the universities, where their special knowledge of current manufacturing techniques, for example, would be valuable.

The last section of the report is devoted to the co-ordination of radio research. The setting up under D.S.I.R. aegis of the Angwin committee, appointed for the purpose of formulating in detail "the basic or fundamental research problems in telecommunications which require investigation", is welcomed. On this committee are represented the Telecommunications Engineering and Manufacturing Association, the Radio Industry Council, Cables and Wireless Ltd., the War Office and the D.S.I.R. Another piece in the pattern of co-ordination is the Radio Components Research Committee of the Ministry of Supply, and the report recommends that the work of this committee should be continued in a wider field, not only to meet the continuing needs of the armed services but also to enhance the technical merit of British commercial radio components and equipment. An intelligence service comparable to the Central Radio Bureau and perhaps operating under D.S.I.R. auspices should be set up to collate information about research proceeding in academic, Service and industrial laboratories.

Night Sky in October

The Moon.—New moon occurs on October 14d 06h 10m, U.T. and full moon on October 29d 20h 07m. The following conjunctions take place:

October			
8d 21h	Mars in conjunction with the moon,	Mars	4 S.
9d 22h	Saturn ,,	Saturn	5 S.
16d 04h	Mercury ,,	Mercury	4 S.
17d 05h	Jupiter ,,	Jupiter	1 N.

In addition to these conjunctions with the moon, Mercury is in conjunction with Venus on October 29d 09h, Mercury being 2·7 S.

The Planets.—Mercury is an evening star, but sets too soon after the sun for favourable observation. Venus, also an evening star, is too close to the sun to be well observed. Mars, in the constellation of Cancer, rises at 23h 37m, 23h 25m, and 23h 09m at the beginning, middle, and end of the month, respectively. Jupiter in the constellation of Scorpius, can be seen in the earlier portion of the night, setting at 19h 17m, 18h 29m, and 17h 35m, at the beginning, middle and end of the month, respectively. Towards the end of October, Jupiter is very close to the star β Scorpii, which will assist in identifying the planet. Saturn, in the constellation of Leo, cannot be seen in the earlier part of the night. It rises at 1h 26m, 0h 38m, and 23h 42m at the beginning, middle, and end of the month, respectively, and can be easily identified by its position with reference to the bright star Regulus of which it is a little west and continues to move closer to it throughout the month.

Those who have the opportunity to study the cluster of stars known as the Pleiades will find much in this group to interest them. It is part of the constellation of Taurus. If there is any doubt, remember that at the beginning of October it is due east and at an altitude of just over 30° about 22½h, that is, at 10h 30m P.M. (G.M.T.). There are six stars visible to the naked eye, though some people can observe more than this, and scores can be seen with the aid of field glasses. The astronomer's photographic plates show that there are many hundreds of stars in this cluster. The brightest star in the Pleiades is η Tauri, generally known as Alcyone, and is near the centre of the group. Seen with even a small telescope it is a very beautiful object and has a companion of magnitude 6·5 which is beyond the range of vision of the naked eye. (The limit of magnitude for the unassisted eye, under good conditions, is 6). There is another companion a little fainter, magnitude 7, and a pair of good field glasses should show both of these. In addition, there is a third star fainter still, magnitude 9, which can be seen with a small telescope.

Scientific Film Review

HYDROGRAPHERS have called to their aid a precision instrument which should earn the gratitude of every country whose economy depends on the safe entry of shipping into her ports. The instrument is the echo sounder, and the film 'Precision Echo Sounding' explains the use of this instrument in the accurate hydrographic survey of a harbour channel.

As the commentary points out, the age-old method of sounding by lead and line is most untrustworthy. The large draughts of modern ships makes the cost of maintaining channels with an adequate safety margin considerable. In consequence the depths of channels are held to close limits, and only the echo sounder can depict these depths with sufficient accuracy and speed.

The film goes on to explain the manpower and equipment necessary to carry out a survey, the operation of the echo sounder in the survey launch, the means of accurately fixing the position of the sounding transits on the face of the chart, and the use of the bar-check for calibrating the record to the true depth below waterline. The real hard work begins when the surveyors come ashore with a long ribbon of paper on which the secrets of the channel bottom are concealed. Nothing, apparently, is right with the record. The depth readings have to be corrected to the bar-check readings and the result again related to tide readings taken at times synchronised with the times of sounding. Finally the readings are again related to port low-water datum. The essential information can then be transferred to a chart and upon this can be based detailed hydrographic work—dredging quantities, position of obstructions and so on.

To people who are interested in the safety of ships entering port this film presents a warm account of the operation of precision echo-sounding. Warm, because a day in the life of an echo sounder is seen also as a day in the lives of the people who have the depths of British shipping channels at their finger tips. With skilful direction the surveyor and his staff become personalities who move briskly about their business without any faltering or fumbling. The fact that the eye of a camera is peering at them apparently means little to hydrographers absorbed in their work.

The technical information is equally well presented, but, with such a complex series of operation to depict, it has not been possible to bring out fully some of the more intricate details. Some knowledge, on the part of the audience, of chart work and draughtsmanship must be presupposed if the finer details of procedure are to be fully appreciated. The speed with which the operations are covered in the film requires a facile brain to keep up with the picture, to the accompaniment of a rather wordy commentary. A short recapitulation of the principal operations would perhaps have enabled slow thinkers like the reviewer to catch up at the end.

To sum up—a smooth and satisfying film for those who are willing to think as well as watch. Good photography and diagrams; a little talkative.

To a young fellow looking for a career with a maritime connexion this film might well suggest the answer to his needs. For the life of a hydrographer appears to be extremely interesting. The film is also the harbourmaster's answer to people who have been known to doubt the accuracy of charts after unhappy contact with an adhesive piece of harbour bottom. The harbourmaster, with the backing of the hydrographers, will always be right. And so will the chart.

The film 'Precision Echo Sounding' was made by Basic Films Ltd. It is available from Henry Hughes and Son, New North Road, Barkingside, Ilford; 35 mm. and 16 mm. sound copies are available. 3 reels; running time, 23 minutes.

P. B. ARMITAGE.

(This review is contributed by arrangement with the Scientific Film Association).

Printed and published in Great Britain by Jarrold & Sons, Ltd., The Empire Press, Norwich.

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